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(54) **A ROTARY EXPANSIBLE CHAMBER DEVICE, AS A COMPRESSOR OR AN EXPANDER**

(57) A rotary expansible chamber device, as a compressor or an expander, comprising a housing having an interior surface and defining an inlet and an outlet, a shaft defining an axis of rotation and being supported in the housing, a rotor mounted within said housing and on said shaft, forming a preferably circular circumference and having a plurality of sealing vanes supported on the rotor to move radially to and from a retracted condition and an extended condition, wherein said interior surface and said circumference radially define a compressor or expander chamber extending from said inlet to said outlet and defining a maximum radial gap between said interior surface and said circumference, and a bypass chamber extending from said inlet to said outlet and defining a minimum radial gap between said interior surface and the circumference of said rotor, characterized in that a dynamic seal is positioned in the bypass chamber such that a fluid is prevented to short cut from a high pressure side to a low pressure side via said bypass chamber.

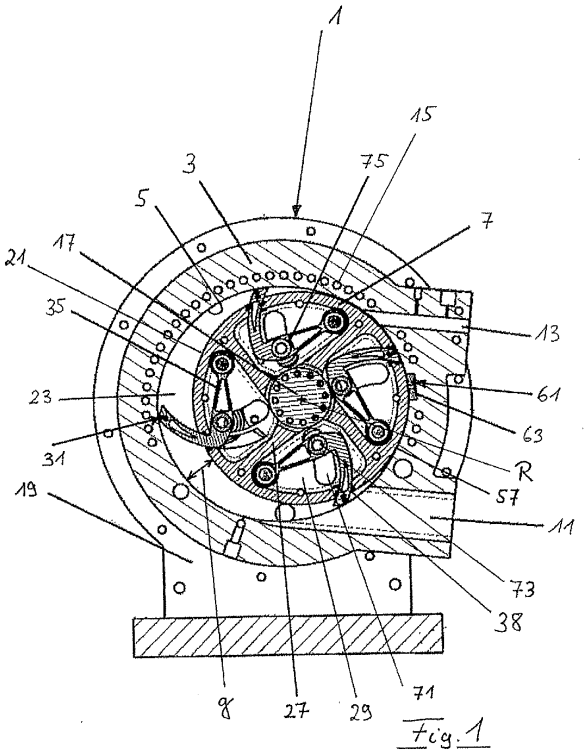

Fig. 1

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Description

[0001] The invention refers to a rotary expansible chamber device. Particularly, the invention refers to a compressor or an expander.

[0002] A compressor shall increase pressure of a fluid by reducing its volume. An expander usually generates electrical energy by driving a rotor by means of the expansion of a compressed fluid.

[0003] A rotary expansible chamber device according to the first part of independent claims is described in US 5,709,188. An operation mode of said device as a compressor is shown in figure 2 of US 5,709,188. The known compressor comprises as main parts a housing defining an inlet and an outlet and a more or less circular cavity, in which a rotor having a circular outer circumference is rotatably mounted. The rotor is driven by a shaft defining an axis of rotation and being supported in the housing of the compressor. As can be seen in figure 2 of US 5,709,188, the rotor supports a plurality of pivotable sealing vanes which can move from a retracted position to an extended position out of the rotor. Between the circular circumference of the rotor and an interior surface of the housing a compressor chamber is confined which defines a radial gap which decreases from the inlet to the outlet. The sealing vanes shall be positioned such that a seal tip may contact the interior surface of the housing. The seal tip is fixed at a substantially radially extending, arcuate arm of the sealing vane. A bypass chamber from the outlet to the inlet is structurally necessary and defines a minimum radial gap between the interior surface of the housing and the circumference of the rotor.

[0004] The known rotary expansible chamber device according to U 5,709,188 suffers from the disadvantage that compressed gas at the high pressure side the outlet short cuts directly to the low pressure side of the inlet via said bypass chamber which reduces compressor effectiveness.

[0005] It is an object of the invention to overcome the disadvantages of the prior art, in particular to provide a rotary expansible chamber device which has an improved system effectiveness.

[0006] This object is solved by the features of independent claim 1. According to the invention, a dynamic seal is positioned in said bypass chamber such that a fluid, particularly, a gas, is prevented to short cut from the high pressure side - in case of a compressor, from the outlet of the housing and, in case of an expander, from the inlet of the housing - to the low pressure side - in case of a compressor, to the inlet of the housing and, in case of an expander, to the outlet of the housing - along said bypass chamber. The function of the end seal is to prevent leakage of compressed fluid. The dynamic seal is in constant physical contact with the preferably circular outer circumference or surface of the rotor and comprises a mating surface regarding the curvature of the outer circumference of the rotor.

[0007] Preferably, the dynamic seal is made of an elastic material having a high wear resistance. Preferably, the dynamic seal is made of fiber reinforced elastomer material.

[0008] Further, it was found out surprisingly that because of the implementation of a dynamic seal in the bypass chamber, the maintenance period for the rotary expansible chamber device could be extended as the wear of the tip seal of the sealing vane is reduced. Because of the dynamic seal, the sealing vane can be retracted during travelling through the bypass chamber such that the seal tip will not be in contact with the interior surface of the housing confining said bypass chamber. The task of sealing is completely taken over by the dynamic seal. In case of wear, only the dynamic seal needs to be exchanged which is much less costly than exchanging all seal tips of the sealing vanes.

[0009] According to a preferred embodiment of the invention, in the interior surface of the housing confining said bypass chamber a pocket is formed, in which the dynamic seal is fixedly received.

[0010] Preferably, the dynamic seal comprises a lip sealingly the contacting the circular circumference of the rotor. Further, the dynamic seal can comprise a sealing surface which is formed matingly to the outer profile of the circumference of the rotor.

[0011] According to a further development of the invention, the dynamic seal defines a sealing axis forming an angle with respect to the axis of rotation of the rotor. By this, shock loads might be prevented due to an interaction between the sealing surface of the dynamic seal and discontinuities of the outer surface of the rotor.

[0012] In a preferred embodiment of the invention, the dynamic seal extends from the interior surface of the housing such that the dynamic seal radially overcomes said minimum radial gap of the bypass chamber.

[0013] According to a further independent aspect of the invention which can be combined with the above-mentioned inventive aspect of a dynamic seal, the rotary expansible chamber device comprises the rotor which supports a plurality of sealing vanes such that they can move radially between a retracted condition and an extended condition.

[0014] According to the invention, each sealing vane comprises a seal tip which is received in a recess formed in a supporting arm of the sealing vane such that said seal tip can be moved within said recess from a retracted position into an extended position in which it protrudes out of a radial end of said supporting arm for sealingly contacting said interior surface of the housing.

[0015] According to this inventive measure, charges applied to the sealing tip of the sealing vane, as shocks or impacts, can easily be absorbed by the seal tip through its movable support in the supporting arm of the sealing vane.

[0016] In a preferred embodiment of the invention, the seal tip constitutes a stop preventing a further movement beyond said extended position of said seal tip within the recess.

[0017] Particularly, said seal tip is formed as an "L" or a "T" at least one short leg of said seal tip forming said stop. Preferably, said recess has an L- or a T-sectional form defining an undercut cooperating with said stop of the seal tip.

[0018] In a preferred embodiment of the invention, the seal tip, before passing said dynamic seal, particularly when entering said bypass chamber, is retracted in order to prevent friction with said interior surface of the housing. The dynamic seal remains ever in contact with said interior surface such that compressed fluid is prevented to short cut from the high pressure side to the low pressure side via said bypass chamber.

[0019] Preferably, for controlling the position of the sealing vanes, each sealing vane comprises a guide bearing means cooperating with a track means formed by the interior surface of the housing. Said track means consists of an inner guiding surface running circumferentially around said axis of rotation of said shaft and pointing to said axis of rotation, said inner guiding surface being configured such that, before passing said dynamic seal, particularly when entering said bypass chamber and before leaving said bypass chamber, said guide bearing means cams on the inner guiding surface such that said sealing vane and therefore said seal tip, is retracted so as to cause a radial gap between said seal tip and the interior surface of the housing and/or the dynamic seal.

[0020] By this inventive measure, a contact and a collision of the seal tip with the housing along the bypass chamber and with the dynamic seal are prevented. Consequently, the wear of the seal tip is reduced. The sealing function is taken over by the dynamic seal.

[0021] In a preferred embodiment of the invention, said supporting arm of the vane is arcuate about a radius from a sealing vane pivot axis which is parallel and radially offset to the axis of rotation of the rotor. Said recess is formed straightly in the supporting arm of the sealing vane such that is crosses said radius of said supporting arm.

[0022] In a further development of the invention, the dynamic seal is connected to a source of lubricant to minimize the wear of the dynamic seal and to reduce friction losses.

[0023] Further feature, advantages and characteristics of the invention will become obvious by the following description of a preferred embodiment of the invention by means of the enclosed drawings, in which:

Figure 1 is a cross sectional view of a compressor according to the invention;

figure 2 is a side view of an arm-structure of a sealing vane; and

figure 3 a detailed side view of the area III according to figure 2.

[0024] In figure 1 the rotary expansible chamber device is shown in form of a compressor and designated in general with reference number 1.

[0025] The compressor 1 comprises as main part a housing 3 defining a circular interior surface 5 and a rotor 7 which is rotatably mounted within the housing 3. The interior surface 5 confines a circular internal space of the housing 3.

[0026] The housing 3 comprises an inlet 11 and an outlet 13. The gas to be compressed enters the housing via the inlet 11 and compressed gas leaves the housing 3 via the outlet 13.

[0027] The housing 3 comprises cooling channels 15 for cooling in particularly the interior surface 5 of the housing 3 heated by compressed air. The housing 3 has a basic side plate forming sides of the compressor chamber and comprising a portion 8 for fixing the compressor to a further structure (not shown).

[0028] The rotor 7 forming a circular outer surface 21 is fixedly supported on a shaft 17. The shaft 17 is rotatably supported on the housing 3 and defines a rotation axis R which is positioned eccentrically to a center (not shown) of the circular interior surface 5 of the housing 3. By this eccentric position of the rotor relative to the interior surface 5, a sickle-shaped compressor chamber 23 is confined and defines a substantially radial gap g between the circular outer surface 21 of the rotor 7 and the interior surface 5 of the housing 3. Said radial gap g increases along the compressor chamber 23 starting from the inlet 11 to a maximum at about the circumferential half of the compressor chamber 23 from which maximum the radial gap g decreases along the chamber via the outlet 13.

[0029] In general, the rotor 7 is formed as hollow structure. According to the cross section of figure 1, the rotor has a shape like a wheel rim including several struts 27 defining four separated compartments or internal cavities 29. Said cavities 29 are confined by radial inner surfaces of the rotor sides. Inside of said cavities 29 of the rotor 7, four vanes 31 are pivotly mounted each sealing vane comprising an L-shaped arm structure 33 which is shown in more detail in figure 2 and 3. A supporting L-leg 35 of the arm structure 33, being proximal to a pivot axis P, is pivotly supported in said cavity 29 of the rotor 7 such that the sealing vane 31 can be pivoted from an extended position (see figure 1) in which a free ended working L-leg 36, being distal to said pivot axis P, extends through an opening 38 formed in the outer surface 21 of the rotor 7 to the outside of the rotor 7 in the compressor chamber 23 to the interior surface 5 of the housing 3. The pivot axis P is fixed by a bearing mounted on the rotor body which allows the vane 31 to rotate with the rotor 7 and allows free swing motion of the vane relative to the rotor 7.

[0030] The free ended working L-leg 36 of the arm structure 33 is angularly (approximately vertical) positioned to the supporting L-leg 35. The free ended working L-leg 36 is substantially curved about a radius from said pivot axis P. At the free end 41 of the free ended working L-leg 35 a slit 43 is formed which comprises, in a section

view, an L-shape with an undercut 47.

[0031] Within said slit 43 a tip seal 51 is arranged having, in a section view an L-shape corresponding to the shape of the slit 43. The tip seal 51 is received within the slit 43 such that it can be moved from an extended position which is shown in figure 3, and a retracted position which is not shown in the figures. As can be seen from figure 3, a clearance c is provided between the tip seal 51 in its extended position and a bottom 55 of the slit 43. Said clearance c is dimensioned such that the tip seal 51 can be retracted such that the free end of the tip seal 51 is completely inside the slit 43. The space between the bottom 55 and the slit 43 and tip seal 51 can be filled by a damping fluid or spring.

[0032] By the movable tip seal 51 it is possible to absorb profile changes, shock or impact forces applied to the tip seal 51 which impacts or shocks may be generated by discontinuities of the interior surface 5 of the housing 3.

[0033] As visible in figure 1, the compressor chamber 23 is the long connecting way from the inlet 11 to the outlet 13 of the housing, however, a short cut way 57 is to be considered by a narrow gap between the outer surface 21 of the rotor 7 and the interior surface 5 of the housing 3. For preventing a pressure loss from the high pressure side on the outlet 13 via said short cut way 57 to the inlet 11 being the low pressure side, a dynamic end seal 61 is fixedly received in a pocket 63 formed in the interior surface 5 of the housing 3. Said dynamic end seal 61 comprises a sealing surface which is formed complementarily to the circular outer surface 21 of the rotor 7. Furthermore, a seal axis (not drawn) is aligned at an angle with the rotation axis R of the rotor 7. This is to prevent shock loads due to the interaction between the sealing surface of the dynamic seal and discontinuities of the outer surface, i.e. the opening 38.

[0034] As also visible in figure 1, the vane 31 is guided and piloted by means of an arcuate open slot 71 formed in a radial wall of the rotor 7. A guide bearing member 73 is constituted by a roller bearing 75 on each axial side of the sealing vane one the roller 75 being visible in figure 1. The guide bearing member 73 cooperates with a track means (not shown in the drawings) which functions as a cam structure formed by the interior surface of the housing 3. The track means comprises an inner guiding surface running at least partially circumferentially around the axis of rotation R, in particularly associated to the short cut way 57 between the inlet 11 and the outlet 13, and pointing to said axis of rotation R of the shaft 17. The roller bearing 75 of the guide bearing member 73 runs on the inner guiding surface of the track means as a cam and make the sealing vane to retract radially inwardly away from the interior surface 5 of the housing 3 as soon as the vane 31 passes the outlet 13 to rotate to the inlet 11 of the housing 3. Therefore, by the retraction of the vane 31 radially inwardly, the tip seal 51 will depart from the interior surface of the housing whereby wear of the tip seal 51 can be reduced. Further, the tip seal 51 will not contact the dynamic end seal 61 by which both the wear of the dynamic end seal and the wear of the tip seal is reduced.

[0035] To bring back the seal tip of the vane 31 into contact with the interior surface 5 of the housing 3, the track means also comprises an outer guiding surface also running at least partially circumferentially around said axis of rotation R of the rotor 7 and pointing away from said axis of rotation R and getting in contact with the bearing member as soon as the vane 31 has passed the inlet 11 or the dynamic end seal 61 in order to bring back the vane 31 in the extended position for generating a sealing contact between the tip seal 51 and the interior surface 5 of the housing 3.

[0036] It is understood that the features of the invention as disclosed in the above description, in the drawings and as claimed may be essential to achieving the invention both by themselves or in any combination.

List of reference signs

[0037]

1	compressor
3	housing
5	interior surface
7	rotor
11	inlet
13	outlet
15	cooling channels
17	shaft
19	side plate
21	outer surface of the rotor
23	compressor chamber
27	strut
29	cavity
31	sealing vane
33	arm structure
35	supporting L-leg
36	free ended working L-leg
38	opening
41	free end
43	slit
47	undercut
51	tip seal
55	bottom
57	short cut way
61	dynamic end seal
63	pocket
71	slot
73	guide bearing member
75	roller bearing
c	clearance
g	gap
P	pivot axis
R	rotation axis

Claims

1. A rotary expansible chamber device, as a compressor (1) or an expander, comprising:

   - a housing (3) having an interior surface (5) and defining an inlet (11) and an outlet (13);
   - a shaft (17) defining an axis of rotation (R) and being supported in the housing (3)
   - a rotor (7) mounted within said housing (3) and on said shaft (17), forming a preferably circular circumference and having a plurality of sealing vanes (31) supported on the rotor (7) to move radially to and from a retracted condition and an extended condition,

   wherein said interior surface (5) and said circumference radially define a compressor (1) or expander chamber extending from said inlet (11) to said outlet (13) and defining a maximum radial gap (g) between said interior surface (5) and said circumference, and a bypass chamber extending from said inlet (11) to said outlet (13) and defining a minimum radial gap (g) between said interior surface (5) and the circumference of said rotor (7),
   characterized in that a dynamic seal is positioned in the bypass chamber such that a fluid is prevented to short cut from a high pressure side to a low pressure side via said bypass chamber.

2. The rotary expansible chamber device according to claim 1, **characterized in that** in the interior surface (5) of the housing (3) confining said bypass chamber a recess is formed in which the dynamic seal is received.

3. The rotary expansible chamber device according to claim 1 or 2, **characterized in that** said dynamic seal (61) comprises a lip sealingly contacting the circumference of the rotor (7).

4. The rotary expansible chamber device according to one of the preceding claims, **characterized in that** the dynamic seal (61) extends from the interior surface (5) such that the dynamic seal (61) radially over comes said minimum radial gap (g) in the bypass chamber.

5. A rotary expansible chamber device, as a compressor (1) or an expander, particularly according to one of the preceding claims, comprising:

   - a housing (3) having an interior surface (5) and defining an inlet (11) and an outlet (13);
   - a shaft (17) defining an axis of rotation (R) and being supported in the housing (3)
   - a rotor (7) mounted within said housing (3) and on said shaft (17), forming a preferably circular circumference and having a plurality of sealing vanes (31) supported on the rotor (7) to move radially to and from a retracted condition and an extended condition,

   wherein said interior surface (5) and said circumference radially define a compressor (1) or expander chamber extending from said inlet (11) to said outlet (13) and defining a maximum radial gap (g) between said interior surface (5) and said circumference, said sealing vanes (31) sealing a radial gap (g) of the chamber between said interior surface (5) of the housing (3) and said rotor (7), said gap (g) extending along said chamber (23) and decreasing from said maximum to a minimum, said sealing vanes (31) comprising a supporting arm and an elongated seal tip (51),
   characterized in that said seal tip (51) is received in a recess formed in said supporting arm such that said seal tip can be moved within said recess from a retracted position into an extended position in which it protrudes out of a radial end of said supporting arm for sealingly by contacting said interior surface (5) of the housing (3).

6. The rotary expansible chamber device according to claim 5, **characterized in that** said seal tip (51) comprises a stop preventing a further movement beyond said extended position of said seal tip (51) in the recess.

7. The rotary expansible chamber device according to claim 5 or 6, **characterized in that** said seal tip (51) is formed as an "L" or a "T" , at lest one short leg of said seal tip (51) forming said stop.

8. The rotary expansible chamber device according to claim 6 or 7, **characterized in that** said recess has an L- or a T-sectional form defining an undercut (47) cooperating with said stop of the seal tip (51).

9. The rotary expansible chamber device according to one of the claims 1 to 8, **characterized in that** said seal tip (51), before passing said dynamic seal, particularly when entering said bypass chamber extending from said inlet (11) to said outlet (13) and defining a minimum radial gap (g) between said interior surface (5) and said circumference, is retracted in order to depart from said interior surface (5), the dynamic seal remaining in contact with said interior surface (5) of the housing (3) such that compressed fluid is prevented to short cut in between a high pressure side and a low pressure side via said bypass chamber.

10. The rotary expansible chamber device according to one of the claims 5 to 9, **characterized in that** for controlling a position of the sealing vanes (31), each

sealing vane (31) comprises a guide bearing means cooperating with a track means formed by the interior surface (5) of the housing (3), said track means constitutes an inner guiding surface running circumferentially around said axis of rotation (R) of said shaft (17) and pointing to said axis of rotation (R), said inner guiding surface being configured such that, before passing said dynamic seal, particularly when entering said bypass chamber and before leaving said bypass chamber, said guide bearing means cams on the inner guiding surface such that said sealing vane (31), particularly said seal tip (51), is retracted in order to cause a radial gap (g) between said sealing vane (31), particularly said seal tip (51), and the interior surface (5) of the housing (5) and/or the dynamic seal.

11. The rotary expansible chamber device according to one of the claims 5 to 10, **characterized in that** said supporting arm is arcuate about a radius from a sealing vane (31) pivot axis (P) parallel and radially offset to the axis of rotation (R), wherein said recess is formed straightly by crossing said radius of said supporting arm.

12. The rotary expansible chamber device according to one of the claims 5 to 11 **characterized in that** the dynamic seal is connected to a supply of lubricant.

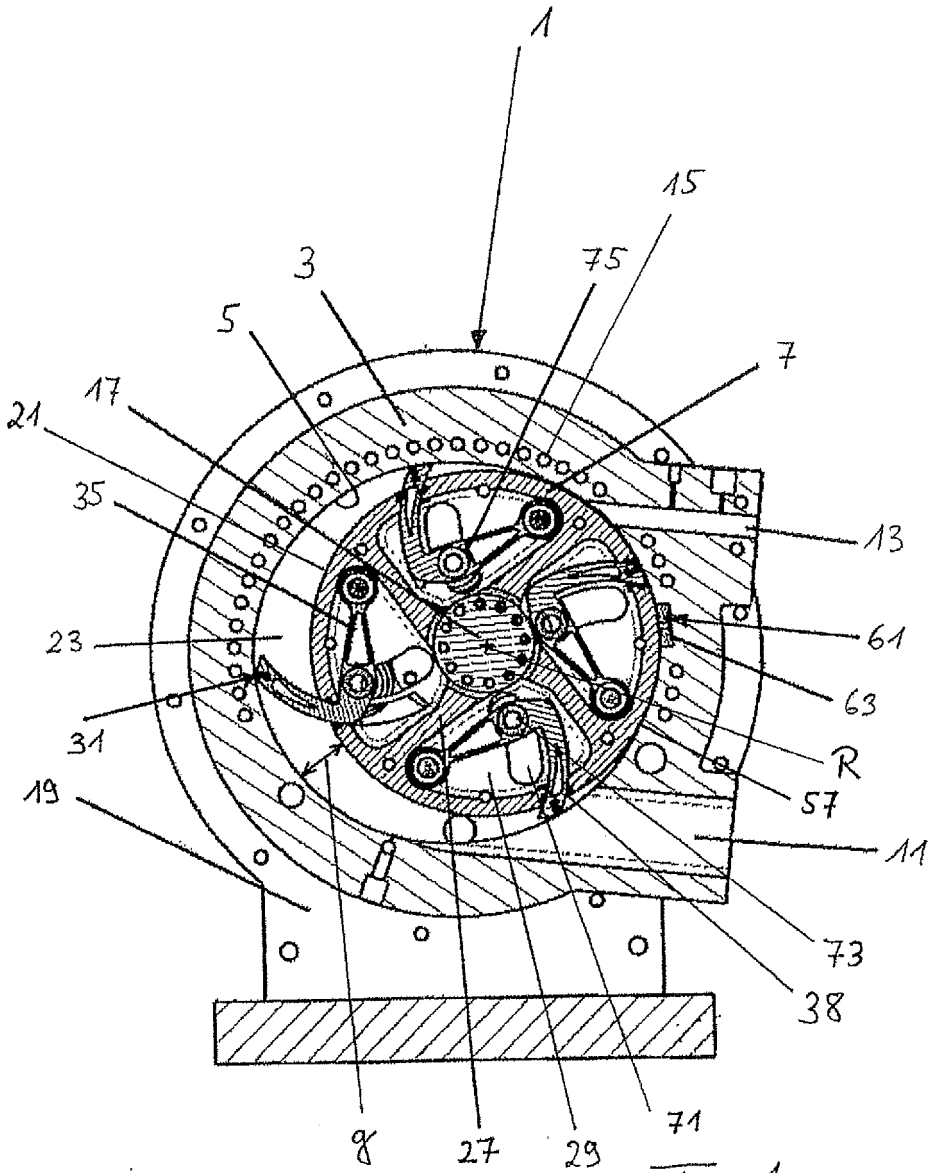

Fig. 1

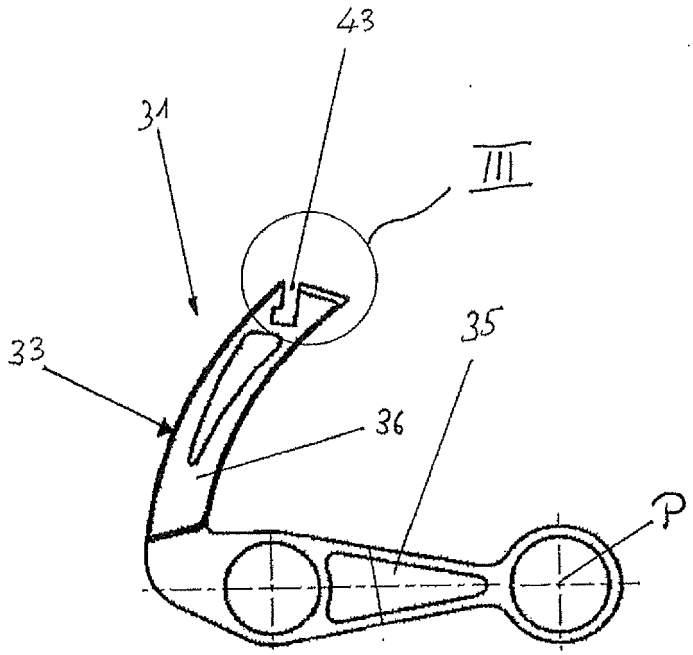

Fig. 2

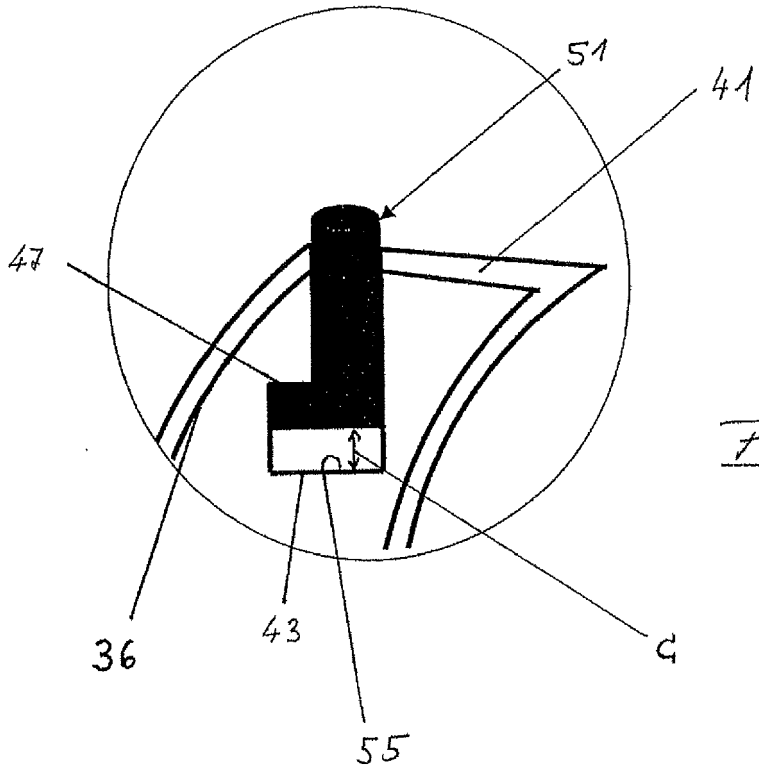

Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 17 20 1535

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 Y	US 1 645 069 A (PETERSON FRANCIS C) 11 October 1927 (1927-10-11) * figures 1-3,6,7 * * page 1, line 98 - line 101 * * page 2, lines 8-12,43-53 * -----	1-4 5-8,11	INV. F01C1/44 F01C19/02 F01C21/08
Y	JP 2000 220401 A (TOYOTA MOTOR CORP) 8 August 2000 (2000-08-08) * figures 2,3 * * abstract * -----	5-8,11	
X	US 3 452 725 A (KELLY DONALD A) 1 July 1969 (1969-07-01) * figures 1,5,6 * * column 2, line 43 - line 65 * -----	1,3,4	

TECHNICAL FIELDS SEARCHED (IPC)

F01C
F04C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	12 March 2018	Pileri, Pierluigi

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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12-03-2018

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 1645069 A	11-10-1927	NONE	
JP 2000220401 A	08-08-2000	NONE	
US 3452725 A	01-07-1969	NONE	

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

REFERENCES CITED IN THE DESCRIPTION

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- WO 5709188 U **[0004]**