



(11) **EP 2 143 879 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
13.01.2010 Bulletin 2010/02

(51) Int Cl.:
F01C 1/44^(2006.01) F01C 21/08^(2006.01)

(21) Application number: **08012339.1**

(22) Date of filing: **08.07.2008**

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

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(54) **Rotary expansible chamber device**

(57) A rotary expansible chamber device, as a compressor or an expander, comprising a housing having an interior surface defining a chamber being open to an inlet and an outlet of said housing, a shaft defining an axis of rotation and being supported in the housing, a rotor mounted within said housing and on said shaft, and having a plurality of sealing vanes supported on the rotor to move radially to and from a retracted condition and an extended condition, said vanes sealing a radial gap between said interior surface of the housing and said rotor, said gap extending along said chamber and decreasing from a maximum to a minimum, each sealing vane having an arm-structure pivotally mounted on said rotor and a guide bearing means projecting therefrom and extending

from said rotor, said housing forming a track means on its interior surface, said guide bearing means contacting and being guided by said track means in order to control each sealing vane to move between the retracted and extended conditions, characterized in that said track means forms an inner guiding surface running at least partly circumferentially around said axis of rotation and pointing to said axis of rotation, and an outer guiding surface running at least partly circumferentially around said axis of rotation and pointing away from said axis of rotation and in that said guide bearing means cooperates with the inner and/or outer guiding surfaces.

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Description

[0001] The invention relates to a rotary expansible chamber device and in particular to a compressor or an expander. An expander can be used as an electrical energy generating device in which a pressurized gas expands for driving a rotor. A compressor is a mechanical device that increases the pressure of gas by consuming energy for driving a rotor and thereby reducing volume of said gas.

[0002] An example for a known compressor or expander is described in US 5,709,188 comprising a housing having an interior surface and defining an inlet and an outlet. The compressor according to figure 2 of US 5,709,188 has a circular rotor mounted eccentrically with respect to a center of a fixed housing such that a compressor chamber is defined between an interior surface of the housing and an exterior surface of the circular rotor. A radial gap between said interior surface of the housing and said rotor decreases along said compressor chamber from a maximum at an inlet to a minimum at an outlet of the housing. Said rotor supports a plurality of sealing vanes to move radially to and from a retracted condition and an extended condition. Said sealing vanes dynamically seal said radial gap when gliding along said interior surface of the housing from the inlet to the outlet of the housing along the compressor chamber so that gas within the compressor chamber will be compressed.

[0003] The compressor chamber is open to the inlet and the outlet of said housing. As said radial gap differs along said compressor chamber, a mechanical vane position control mechanism is necessary in order to retract and extend the sealing vane depending on the circumferential position of the vane with respect to the interior surface of the housing. Said mechanical sealing vane position control mechanism comprises a guide bearing means which is supported on an arm-structure of the sealing vane. Additionally, the mechanical sealing vane position control mechanism comprises a fixed track means formed by the interior surface of the housing. Said guide bearing means of the sealing vane and said track means of the housing cooperate with each other in a coming way such that in each respective circumferential position of the rotor relative to the housing said sealing vane is moved into necessarily retracted and extended position in contact with the interior surface of the housing.

[0004] In US 5,709,188 the track means are realized by a guiding surface running substantially circumferentially around an axis of rotation of the rotor. For compensation of the eccentric arrangement of the rotor with respect to the center of the housing, the interior surface of the housing forms a radially inwardly orientated bump according to which the guiding surface of said track means forms a corresponding bump.

[0005] The inventor of the present application found out that during operation of the known rotary expansible chamber device according to US 5,709,188 a seal tip of the sealing vane might lose contact to the inner surface

of the housing when passing "jumpingly" said bump. Said jumping inertia movement causes a retraction of the sealing vane so that, because of a loss of contact of a seal tip, a pressure loss is to be accepted. In particular, in an operation mode of the expansible chamber device defined by a lower rotation speed of the rotor, the centrifugal forces acting upon the vane will not be sufficient in order to keep the seal tip of the vane in contact to the interior surface of the housing.

[0006] This problem of loss of contact of the sealing tip of the sealing vane does not only appear in the case of radially inwardly orientated bumps in the track means, but also in the case that the curvature of said interior surface of the housing decreases along said chamber so that the vane must be continuously more and more extended in order to follow said interior surface of the housing.

[0007] It is an object of the invention to overcome the disadvantages of the prior art, in particular to provide a rotary expansible chamber device, as a compressor or an expander, according to the first part of independent claim 1, which is improved regarding the compressing and expanding efficiency of the device.

[0008] The object is solved by the subject matter as defined by the features of independent claim 1. Accordingly, said track means forms both an inner guiding surface running at least partly circumferentially around the axis of rotation of the rotor and pointing to said axis of rotation, and an outer guiding surface running at least partly circumferentially around said axis of rotation and pointing away from said axis of rotation. According to the invention, said guide bearing means cooperates with the inner and outer guiding surface, alternatively. Particularly, as soon as the guide bearing means of the vane loses contact of one of the guiding surface, it gets in engagement with the other guiding surface in order to maintain control over the movement of the vane with respect to the interior surface of the housing such that the seal tip of the sealing vane essentially remains in a predetermined controlled position with respect to the interior surface of the housing, preferably in contact with the interior surface of the housing, if desired.

[0009] By the inventive measure in forming both an inner and an outer guiding surface for a track means, a safe contact of the sealing tip of the vane is assured so that a loss of pressure in form of a leak stream of compressed gas passing over the seal tip of the sealing vane can be avoided. Therefore, the efficiency of compression of the rotary expansible chamber device is well improved.

[0010] According to a preferred embodiment of the invention, said guide bearing means is constituted by at least one outer track bearing member cooperating with said inner guiding surface, and by at least one inner track bearing member cooperating with said outer guiding surface of the track means. It shall be clear that preferably the outer track bearing member and the inner track bearing member are structural different elements cooperating with respective differently positioned and formed guiding

surfaces of said track means. According to this aspect of the invention, an automatically working mechanical mechanism for controlling the position of the sealing vane with respect to the interior surface of the housing is provided.

[0011] According to an improvement of the invention, said inner and outer track bearing members are provided on both axial sides of the arm-structure of said sealing vane. Preferably, said track bearing members can each comprise a roller bearing.

[0012] According to a preferred embodiment of the invention, said guide bearing means is mounted relatively to the guiding surface such that, in operation of the device, said guiding bearing means only acts on the inner or the outer guiding surface, alternately. This means that either one of the track bearing means comes into contact with the corresponding one of the inner or outer guiding surfaces while the other track bearing member loses contact to the respective other guiding surface.

[0013] Preferably, in a mounted position, said guide bearing means is in contact with the outer guiding surface, there is a small clearance between said bearing means and said inner guiding surface and vice versa. In particular, said clearance is less than 2 mm or 1 mm.

[0014] Preferably, said outer guiding surface is axially offset to an adjacent inner guiding surface regarding a pivot axis of the arm-structure of the vane.

[0015] In a preferred embodiment of the invention, the inner guiding surface of said track means is arranged axially closer to the arm-structure than said outer guiding surface of said track means.

[0016] In a further development of the invention, the curved courses of the inner and outer guiding surfaces are substantially parallel to each other, consequently, the shortest radial distance between the inner and outer guiding surfaces remains substantially constant along the courses of the inner and outer guiding surfaces.

[0017] For generally controlling the position of the sealing vane, in particular for departing the seal tip from the interior surface of the housing, the guiding surfaces can be designed correspondingly. For example, if it is desired that the seal tip loses contact with interior surface of the housing for reducing wear of the seal tip in the area of the bypass chamber from the outlet to the inlet, said inner guiding surface of the track means may form a protruding bump which faces a corresponding depressing dint formed in said outer guiding surface, said bump in the inner guiding surface and said dint in the outer guiding surface are associated to the course of the seal tip around the interior surface of the housing, namely, in that as soon as the seal tip enters the bypass chamber and leaves the bypass chamber, particularly just before passing the dynamic seal in the bypass chamber.

[0018] Further features, advantages and characteristics of the invention will now be described by a preferred embodiment of the invention on behalf of the enclosed drawings in which:

Figure 1 is a cross sectional view of a rotary expandable chamber device as a compressor according to the invention;

5 figure 2 is a partly broken sectional view of the embodiment according to figure 1 illustrating inner and outer guiding surfaces of a track means;

10 figure 3 is a detailed sectional view of a sealing vane including a guide bearing means in cooperation with an outer guiding surface of the track means while an inner guiding surface is out of service; and

15 figure 4 is a sectional view along the rotation axis of roller bearings for illustrating a pair of outer track bearing members in cooperation with a respective inner guiding surface of a track means, and a pair of inner track bearing members out of service regarding respective outer guiding surfaces of said track means.

[0019] In figures 1 and 2, the rotary expandable chamber device in form of a compressor is designated, in general, with reference number 1.

25 **[0020]** The compressor 1 comprises as main parts, first, a tube-shaped housing 3 defining a circular internal space confined by a circumferential shell and radial side walls (not shown) and defining a circular interior surface 5, and, second, a rotor 7 which is rotatably mounted within the housing 3. The housing 3 defines an inlet 11 and an outlet 13. The gas to be compressed enters the housing 3 via the inlet 11 and leaves the housing 3 via the outlet 13. The housing 3 has a basic side plate forming sides of the compressor chamber and comprising a portion 8 for fixing the compressor 1 to a further structure (not shown).

35 **[0021]** The housing 3 comprises a cooling channels 15 for cooling in particular the interior surface 5 of the housing 3 which will be heated by compressed air. 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 the eccentric position of the rotor 7 relatively to the interior surface 5 a sickle-shaped compressor chamber 23 is formed defining 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 compressor chamber 23 from which maximum the radial gap g decreases along the compressor chamber vers the outlet 13.

40 **[0022]** The compressor chamber extends beyond the outlet 13 into a short cut passage to the inlet 13, which can be designated as a bypass chamber 26 defining a very small radial gap. For avoiding a pressure loss from

the high pressure side of the outlet 13 to the low pressure side in the inlet 11 via said bypass chamber 26, a dynamic end seal 25 is received in a recess formed in the interior surface 5 of the housing 3. The dynamic end seal 25 comprises a sealing surface complementarily formed to the circular outer surface 21 of rotor 7.

[0023] In general, the rotor 7 is formed as hollow structure. According to the cross-section view of figure 1, the rotor 7 has shape like a wheel rim including several struts 27 defining four separated internal compartments or cavities 29. Said cavities 29 are confined by radial inner surfaces of rotor sides. Inside said cavities 29 of the rotor 7, four vanes 31 are pivotally mounted, each sealing vane 31 comprising an L-shaped arm-structure 33 for holding a tip seal 37 which is operated to come into a sealing contact with the interior surface 5 of the housing 3 at least in the area of the compressor chamber 23. A supporting L-leg of the arm-structure 33 is pivotally supported within said cavity 29 around a pivot axis P which 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 31 relative to the rotor 7. Around said pivot axis P, the sealing vane 31 can be pivoted from an extended position in which a free ended working L-leg 35 of the arm-structure 33 extends through an opening 38 formed in the outer surface 21 of the rotor 7 vers the outside of the rotor 7 to the interior surface 5 of the housing 3. At said free end of the free ended L-leg 35 the tip seal 37 is mounted in an L-shaped slit formed in a free end of the free ended L-leg 35 of the arm 33.

[0024] In figure 1, substantially in a circumferential middle of the compressor chamber 23, a sealing vane 31 is shown in its extended position said tip seal 37 being in contact with the interior surface 5 of the housing 3. The sealing vane diametrically positioned to the extended one (31) is in a completely retracted position, i.e. the vane is 31 is situated substantially completely within in the cavity 29 of the rotor 7. If a dynamic end seal 25 is provided in the bypass chamber 26, the vane 31 is retracted such that the tip seal 37 departs from the interior surface 5 of the housing 3 when travelling along the bypass chamber 26. Without the use of a dynamic end seal 25 in the bypass chamber 26, the tip seal 37 may remain in contact with the interior surface 5 of the housing 3 when travelling through the bypass chamber 26 from the outlet 13 to the inlet 11.

[0025] The compressor 1 comprises a mechanical vane position control mechanism for extending and retracting the vane 31 dependently on the circumferential position of the rotor 7. Said mechanical sealing vane position control mechanism comprises a track means 41 which is illustrated in figures 2, 3, and 4.

[0026] Said track means cams on a guiding bearing means and is constituted by a pair of outer track bearing members 43, 45 and a pair of inner track bearing members 49, 51. Each inner and outer track bearing members 43, 45, 49, 51 are formed as a roller bearing supported on a stem 53 which is received in an arc shaped slot 55

(figure 1) formed in a radial wall of the rotor 7 to be substantially radially shifted. When the vane 31 is moved from a retracted position into an extended position, as visible in figure 1, the stem 53 protruding through the respective slot 55, swings freely along the arc shaped slot 55 without physical contact with the rotor body, particularly with the radial wall.

[0027] One inner and one outer track bearing members 43, 49 and 45, 51 are positioned on each axial side of the arm-structure 33 of the vane 31. The roller bearings of the outer track bearing members 43, 45 and the inner track bearing members 49, 51 define a common rotation axis S. Said rotation axis S of the roller bearings travels along the arc shaped recess 55.

[0028] The operation movement of the vane 31 is determined by a first axis being the pivot axis P and a second axis being the rotation axis S of the roller bearing of the track bearing member 43, 45. The second axis S coincides with the axis of the stem 53. The second axis S is fixed with respect to the vane structure and the inner and outer tracking bearing 43, 45, 49, 51 are guided by the inner and outer guiding surfaces 61, 63, 65, 76.

[0029] The mechanical sealing vane position control mechanism further comprises a guide bearing means which is constituted by inner guiding surfaces 61 and 63 facing to the rotation axis R of the rotor 7 and cooperating with respective outer track bearing members 43 and 45. Further, said guide bearing means is constituted by outer guiding surfaces 65 and 67 facing away from the rotation axis R of the rotor 7 and cooperating with respective inner track bearings members 49 and 51. In the operation mode of the compressor according to figure 4, the sealing vane 31 is positioned only by the outer track bearing members 43, 45 being in contact with respective inner guiding surfaces 61, 63 while inner track bearing members 49, 51 are distanced to respective outer guiding surfaces 65, 67.

[0030] All guiding surfaces 61, 63, 65, 67 of said guide bearing means are realized by correspondingly formed portions of the housing 3, particularly respective side plates 8.

[0031] The function of the above defined double track structure of the mechanical sealing vane position control mechanism will be described particularly in reference to figure 2. For reducing wear of the seal tips and the dynamic seal, it is preferred to shape the inner guiding surface 61, 63 in the area of the bypass chamber 26 with a radially inwardly protruded bump 71. It might be understood that, when rotating the rotor 7 according to flash F, the outer track bearing members 43, 45 are in contact with the respective inner guiding surfaces 61, 63 arriving at bump 71. When further rotating according to flash F, the outer track bearing members 43, 45 travels over the bump 71 whereby the outer track bearing members 43, 45 are shifted radially inwardly and the vane 31 is further retracted so that the tip seal 37 loses contact to the interior surface 5 of the housing 3. After the bump 71 has passed, the inner track bearing member will come into contact

with the outer guiding surface 65 to bring back the vane 31 in the extended position and therefore the tip seal 37 into contact with the inner surface of the housing.

[0032] By this structure of the guiding surfaces 61, 65, it is possible to "jump" over the dynamic end seal 25 so that the wear of the seal tip 37 and the dynamic seal 25 can be reduced. Preferably, the inner and outer guiding surfaces 61, 63, 65, 67 can be designed such that the tip seal loses contact to interior surface 5 of the housing 3 as soon as the tip seal 37 travels along the entire bypass chamber 26.

[0033] In general, by a double track structure including inner and outer guiding surfaces 61, 63, 65, 67, it is possible to maintain a predetermined controlled distance between the tip seal 37 of the vane 31 and the interior surface 5 of the housing 3 even in the cases of abrupt profile changes. Said inner track bearing members 49, 51 come immediately in contact with respective outer guiding surfaces 65, 67 of a track means 53 when the outer track bearing members 43, 45 intend to lose contact with respect to inner guiding surfaces 61, 63, and vice versa.

[0034] 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

[0035]

1	expander
3	housing
5	interior surface
7	rotor
8	basic side plate
11	inlet
13	outlet
15	cooling channels
17	shaft
21	outer surface of the rotor
23	compressor chamber
25	dynamic end seal
26	bypass chamber
27	strut
29	cavity or compartment
31	vane
33	L-shaped arm-structure
35	free ended L-leg
37	tip seal
41	track means
43, 45	outer track bearing members
49, 51	inner track bearing members
53	stem
55	slot
61, 63	inner guiding surface
65, 67	outer guiding surface
71	bump
F	flash

g	gap
R	rotation axis
P	pivot axis
S	rotation axis for roller bearing

Claims

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

- a housing (3) having an interior surface (5) defining a chamber (23) being open to an inlet (11) and an outlet (13) of said housing (3);
- 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), 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, said vanes (31) sealing a radial gap (g) between said interior surface (5) of the housing (3) and said rotor (7), said gap (g) extending along said chamber (23) and decreasing from a maximum to a minimum, each sealing vane (31) having an arm-structure (33) pivotally mounted on said rotor (7) and a guide bearing means projecting therefrom and extending from said rotor (7);
- said housing (3) forming a track means on its interior surface (5), said guide bearing means contacting and being guided by said track means in order to control each sealing vane to move between the retracted and extended conditions,

characterized in that said track means forms an inner guiding surface (61, 63) running at least partly circumferentially around said axis of rotation (R) and pointing to said axis of rotation (R), and an outer guiding surface (65, 67) running at least partly circumferentially around said axis of rotation (R) and pointing away from said axis of rotation (R) and **in that** said guide bearing means cooperates with the inner and/or outer guiding surfaces.

2. The rotary expansible chamber device according to claim 1, **characterized in that** said guide bearing means is constituted by at least one inner track bearing member (49, 51) cooperating with said outer guiding surface (65, 67), and by at least one inner track bearing member (49, 51) cooperating with said inner guiding surface (61, 63).

3. The rotary expansible chamber device according to claim 1 or 2, **characterized in that** two inner and/or outer track bearing members (43, 45, 49, 51) are provided on both axial sides of each arm-structure

(33).

4. The rotary expansible chamber device according to one of the preceding claims, **characterized in that** track bearing members (43, 45, 49, 51) each comprise a roller bearing. 5

5. The rotary expansible chamber device according to one of the preceding claims, **characterized in that** said bearing means is mounted relatively to the guiding surfaces (61 to 67) such that, in operation of the device, said bearing means only acts on the inner or the outer guiding surface (61, 63, 65, 67). 10

6. The rotary expansible chamber device according to one of the preceding claims, **characterized in that**, in a mounted condition, if said guide bearing means is in contact with the outer guiding surface (65, 67), there is a clearance between said guide bearing means and said inner guiding surface, and vice versa, wherein in particular said clearance is less than 2 mm or 1 mm. 15
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7. The rotary expansible chamber device according to one of the preceding claims, **characterized in that** said outer guiding surface (65, 67) is axially offset to the inner guiding surface (61, 63). 25

8. The rotary expansible chamber device according to one of the preceding claims, **characterized in that** said inner guiding surface (61, 63) is arranged axially closer to the arm-structure (33) than said outer guiding surface (65, 67). 30

9. The rotary expansible chamber device according to one of the preceding claims, **characterized in that**, particularly in the area of a bypass chamber (26), said inner guiding surface (61, 63) forms a protruding bump which faces a corresponding depressing dint formed in said outer guiding surface (65, 67). 35
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10. The rotary expansible chamber device according to one of the preceding claims, **characterized in that** said either one of track bearing members come into contact with the corresponding one of the inner or outer guiding surface when said either track bearing members had lost contact with respect to the other one. 45

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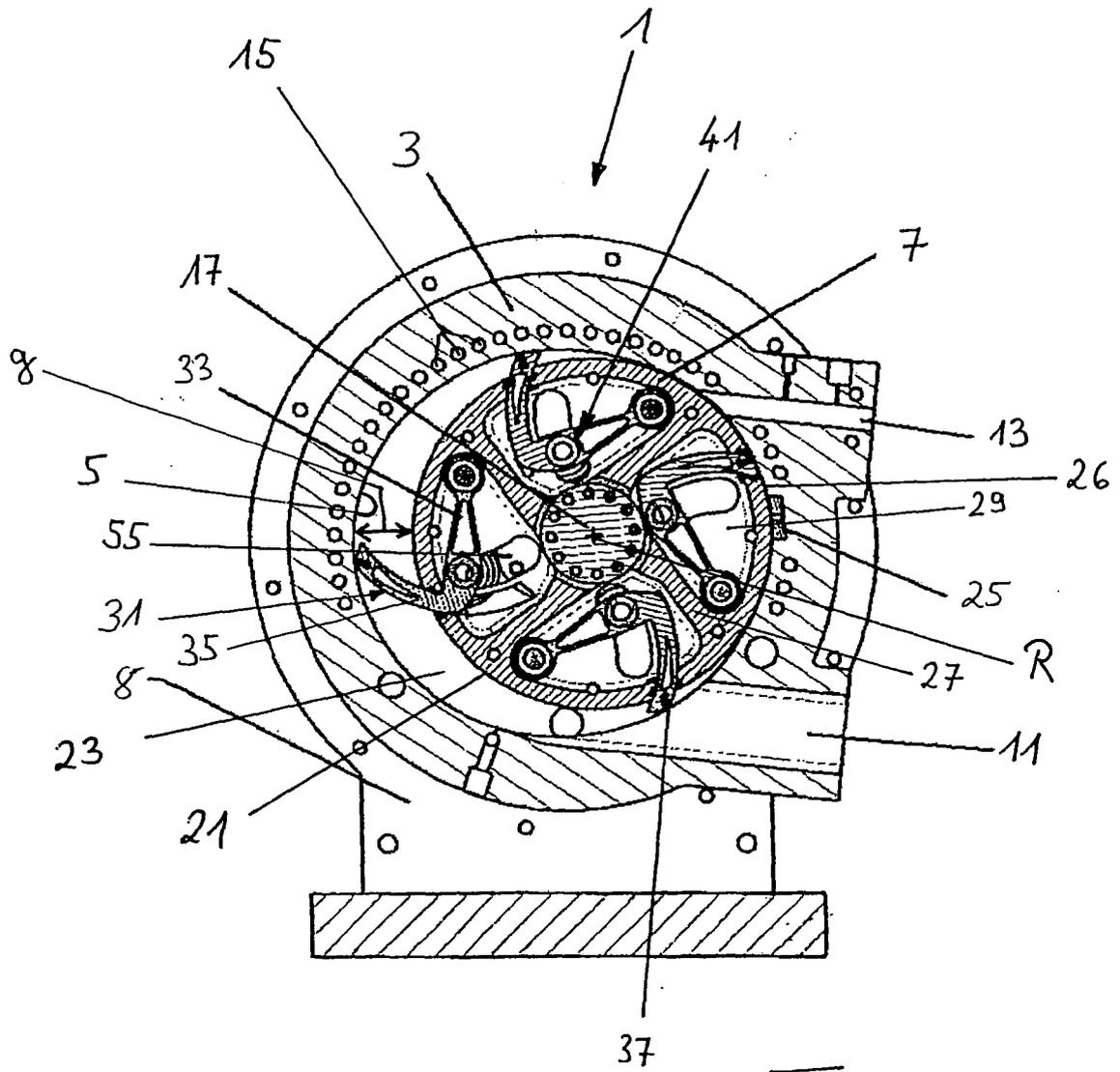


Fig. 1

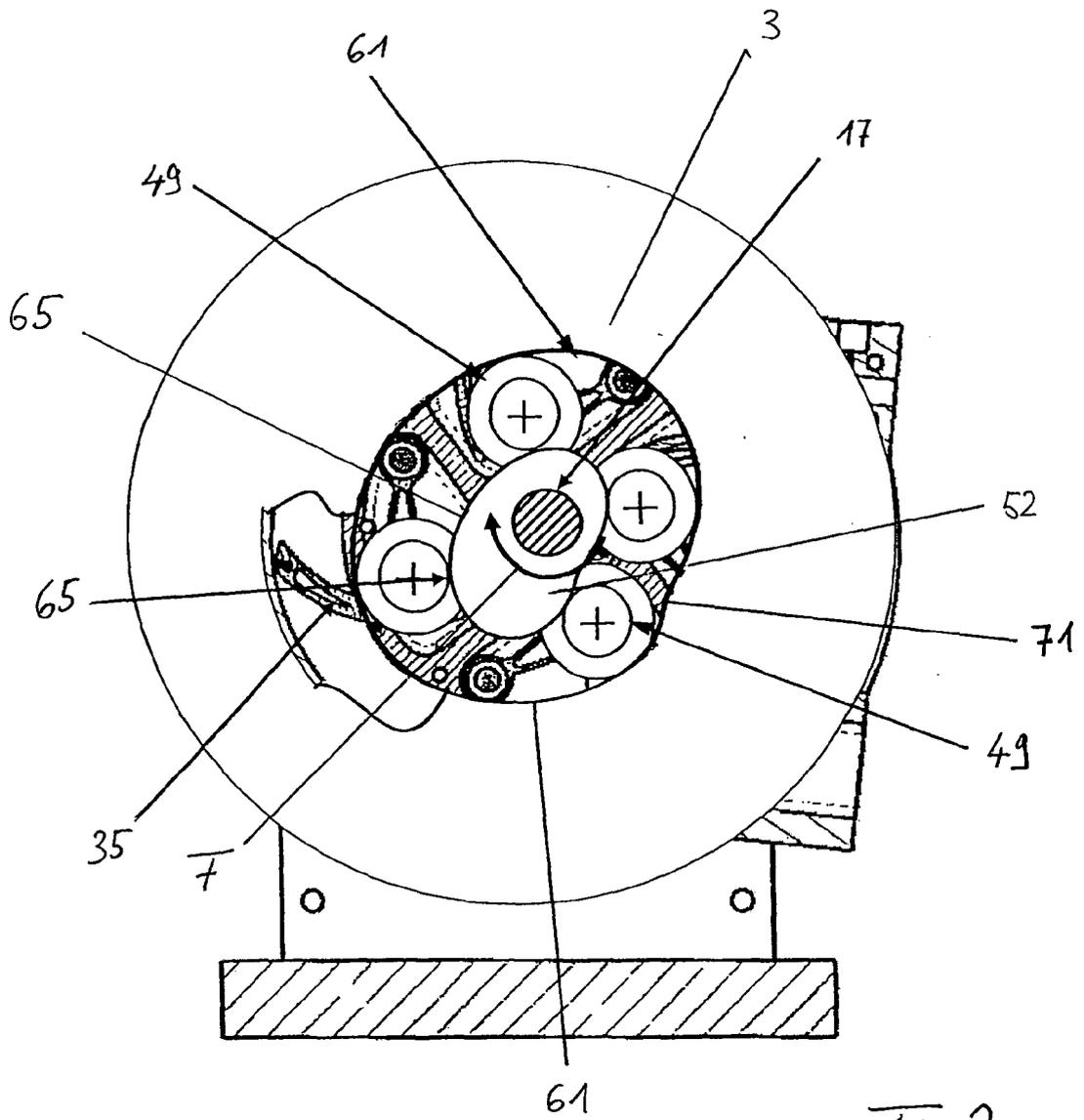
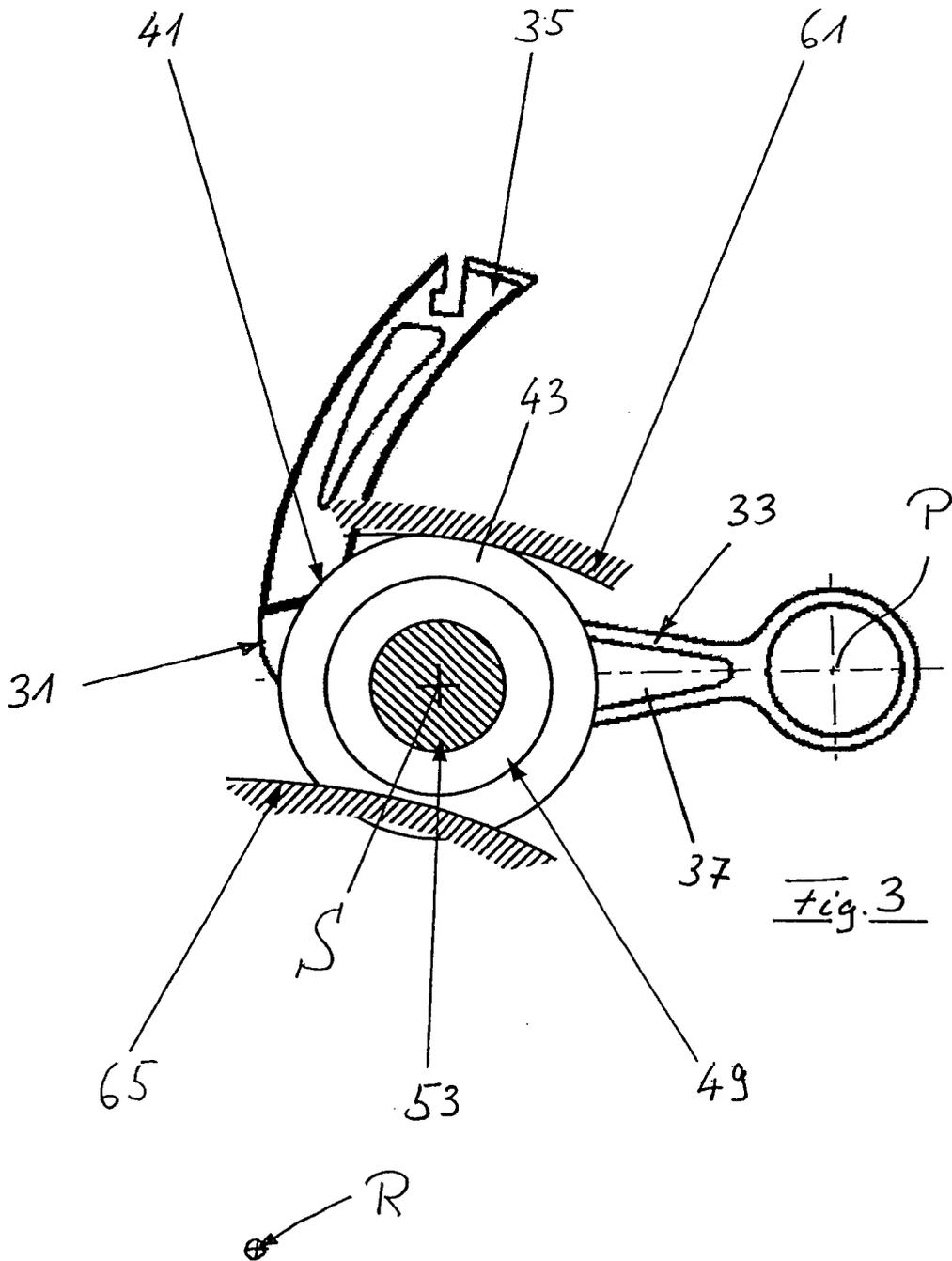


Fig. 2



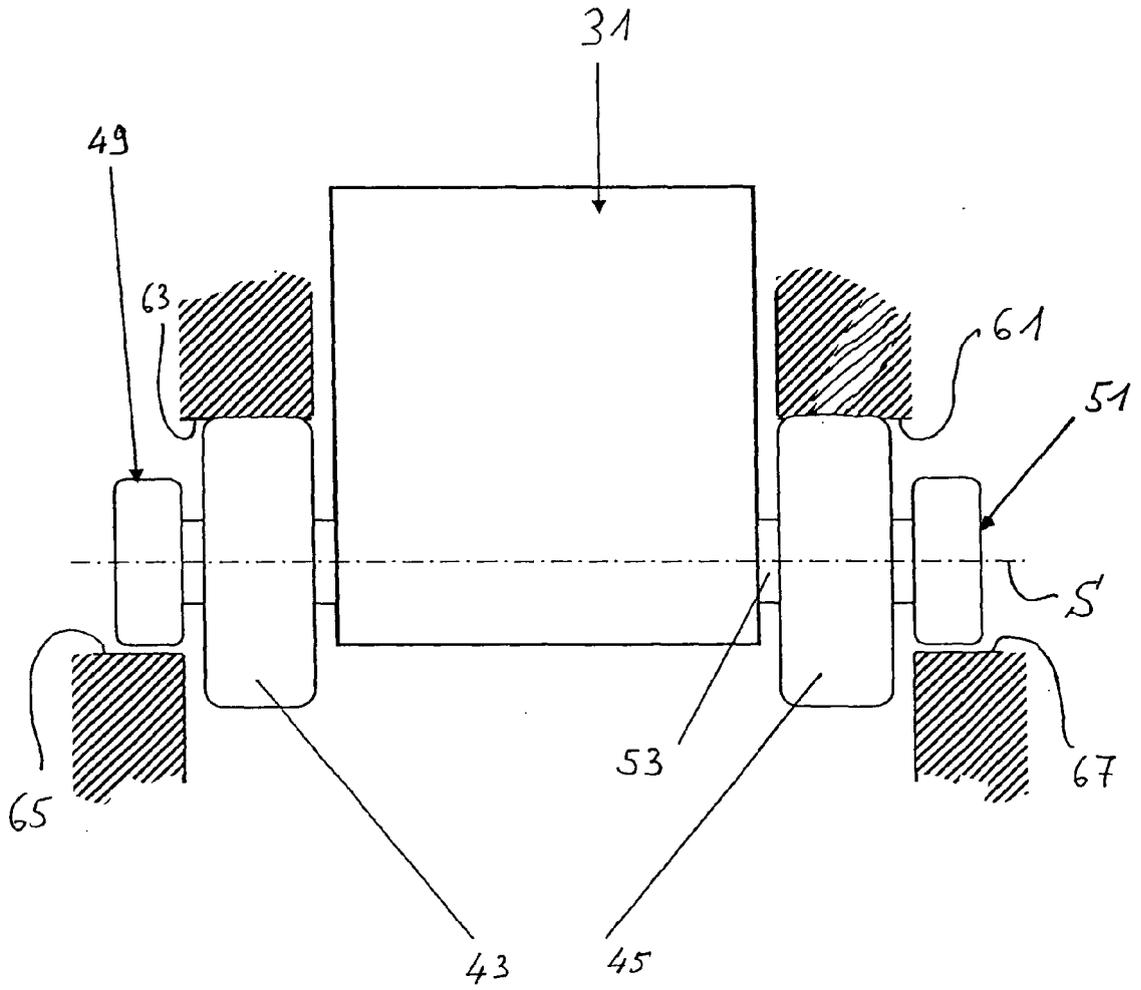


Fig. 4



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**ANNEX TO THE EUROPEAN SEARCH REPORT
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