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(54) VOLUMETRIC MACHINE

(57) A volumetric machine acting on an operating fluid, comprising:
i) a first toothed wheel (21) comprising a first group (210) of teeth that identify interposed between them a first plurality (201) of compartments for the operating fluid;
ii) a second toothed wheel (22) comprising a second group (220) of teeth intended to engage with the teeth of the first group (210);
iii) a casing (3) that defines a housing (30) for positioning the first and the second toothed wheel (21, 22);
iv) a path (4) that extends along a section of said casing (3) and that places in fluid communication at least two compartments of said first plurality (201).

The volumetric machine may be a pump and/or a motor.

The casing (3) comprises at least a first channel (51) distinct from said path (4).

At least in one predetermined configuration assumed by the first wheel (21):
- the first channel (51) places in fluid communication a first and a second compartment (211, 212) of said first plurality (201) which are consecutive and at least partially delimited by a same tooth of the first group (210);
- at least the first compartment (211) of the first plurality (201) being distinct from compartments of the first plurality (201) licked by said path (4);
- said second compartment (212) being licked by the path (4);
- said first compartment (211) being placed upstream of the second compartment (212) and of the compartments of the first plurality (201) licked by said path (4).

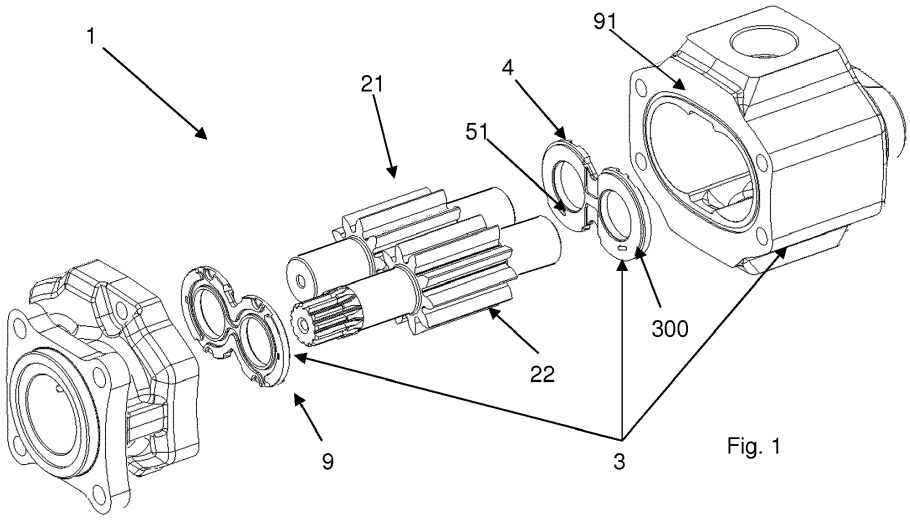


Fig. 1

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Description

[0001] The present invention relates to a volumetric machine acting on an operating fluid, typically oil. This volumetric machine may be a pump or a motor or a machine that allows operation as a pump and as a motor alternatively.

[0002] Volumetric gear pumps are known comprising two counter-rotating toothed wheels that engage with each other.

[0003] They are housed in a closed pump body on two opposite faces by two distinct shims that extend orthogonally to the axis of rotation of the two toothed wheels.

[0004] The casing and the gears define a plurality of compartments for housing an operating fluid that necessarily move together with the toothed wheels that contribute to defining them.

[0005] The need to have high volumetric and hydromechanical performance requires knowing how to accurately control the law of pressurisation the oil compartment during the rotation of the toothed wheels. For this purpose, circumferential processes are used to form pressurisation outlets on the surfaces of the shims.

[0006] They allow oil to be conveyed from the high pressure environment to a compartment in a position defined by the designer. Thus it is certain that as the rotation speed of the pump changes, the axial balance of forces acting on the shims remains constant, preventing the occurrence of seizure (in the event that the shim is excessively pushed towards the toothed wheels) or in low volumetric performance conditions (in the event that the toothed wheels move away from the shim).

[0007] Hence, once the pressure values at the suction and at the delivery have been fixed, the pressure differential imposed on the pump is known. As the pressure differential increases, strong erosion is noted, particularly affecting the outlet end of the pressurisation outlet. This is connected with the fact that the speed of the jet of oil exiting the pressurisation outlet increases as the pressure differential increases, which promotes the establishment of local cavitation phenomena. In practice, bubbles of gas dissolved in the oil (and possibly oil vapour) are formed, which then implode due to the fast pressurisation within the compartment (interposed between two teeth of the toothed wheel) which houses the outlet fluid. All this determines erosion which in a short time comprises the performance and operation of the pump.

[0008] In this context, the technical task underlying the present invention is to propose a volumetric machine which obviates the drawbacks of the known art as described above.

[0009] In particular, an object of the present invention is to provide a volumetric machine able to eliminate/minimise erosive phenomena.

[0010] The stated technical task and specified objects are substantially achieved by a volumetric machine comprising the technical features disclosed in one or more of the appended claims.

[0011] Further characteristics and advantages of the present invention will become more apparent from the approximate and thus non-limiting description of a preferred, but not exclusive, embodiment of a volumetric machine, as illustrated in the accompanying drawings, in which:

- figure 1 shows a simplified exploded view of a volumetric machine according to the present invention;
- figure 2 shows a view of a volumetric machine according to the present invention;
- figure 3 shows an enlargement of a detail of figure 2;
- figure 4 shows a sectional view of a detail of a volumetric machine according to the present invention;
- figure 5 shows a comparative graph;
- figure 6 shows a volumetric machine according to the present invention and alternative to that of figure 2;
- figure 7 shows a volumetric machine according to the present invention, alternative to that of figure 2 or 6;
- figure 8 shows portions of a volumetric machine according to the present invention alternative to that of figure 2 or 6 or 7;

[0012] In the appended figures, reference number 1 denotes a volumetric machine acting on an operating fluid.

[0013] Typically the operating fluid is oil. The volumetric machine 1 is a pump or a motor. It may be a machine that can operate alternatively as a motor or a pump.

[0014] The volumetric machine 1 comprises a first toothed wheel 21.

[0015] The first toothed wheel 21 comprises a first group 210 of teeth that identify interposed between them a first plurality 201 of compartments for the operating fluid. Appropriately the first group 210 of teeth comprises all the teeth of the first wheel 21 (figure 2 for illustrative simplicity 210 indicates only a part of the teeth of the first group). They extend along the circumference.

[0016] The machine 1 comprises a second toothed wheel 22 comprising a second group 220 of teeth intended to engage with the teeth of the first group 210. The teeth of the second group 220 are all the teeth of the second wheel 22 (in figure 2 for illustrative simplicity 220 indicates only a part of the teeth of the second group). Throughout the present description everything described with reference to the first wheel 21 can also be repeated for the second wheel 22. The axis of rotation of the first wheel 21 is parallel and distinct from that of the second wheel 22. The first and the second wheel 21, 22 are one outside the other (they partially co-penetrate at teeth that engage).

[0017] Appropriately the machine 1 comprises a casing 3 that defines a housing 30 for positioning the first toothed wheel 21. Such housing 30 also houses the second toothed wheel 22. The casing 3 is for example made of an aluminium alloy or cast iron.

[0018] The machine 1 comprises a path 4 that extends along a portion of said casing 3. The path 4 may be a groove, for example a bevel. The path 4 places in fluid communication at least two compartments of said first plurality 201. In particular, the path 4 places in communication more than two compartments of the first plurality 201. Appropriately, the path 4 defines a sort of burr. Preferably, the path 4 extends along an arc of a circumference. The path 4 in the case of a pump is called the pressurisation outlet. The path 4 in the case of a motor is known as the depressurisation outlet.

[0019] The casing 3 comprises at least a first channel 51 distinct from said path 4. As exemplified in the figures the first channel 51 is separated from the path 4. They do not intersect.

[0020] At least in one predetermined configuration assumed by the first wheel 21:

- the first channel 51 places in fluid communication a first and a second compartment 211, 212 of said first plurality 201 which are consecutive and at least partially delimited by a same tooth of the first group 210 (the first channel 51 allows a by-pass of the tooth in said predetermined configuration);
- at least the first compartment 211 of the first plurality 201 is distinct from (all the) compartments of the first plurality 201 licked by said path 4 (i.e. the compartments that face the path 4; for example with reference to figure 7 they are the compartments 90c, 90d, 90e, 90f, 90g); in other words the first compartment 211 is not licked directly by the path 4;
- the second compartment 212 is, instead, licked by the path 4;
- the first compartment 211 is placed upstream of the second compartment 212 and of the compartments of the first plurality 201 licked by the path 4. Such predetermined configuration photographs the situation at a particular angle of rotation of the first toothed wheel 21 (for example figure 2, 3, 4, 6, 7).

[0021] Throughout the present description a compartment is defined upstream of another compartment if in the path that goes from an inlet mouth 28 of the fluid into the machine 1 to an outlet mouth 29 of the fluid from the machine 1 it is closer to the inlet mouth 28. For example, in figure 7 the compartment 90a (hypothesizing that it is at the inlet mouth 28) will be upstream of the compartment 90b which is, in turn, upstream of the compartment 90c which is in turn upstream of the compartment 90d, which is in turn upstream of the compartment 90e which is in turn upstream of the compartment 90f which is in turn upstream of the compartment 90g. For example, in the case of figure 2, once the clockwise rotation direction of the first toothed wheel 21 has been set, the inlet mouth 28 will be at the bottom and the outlet mouth 29 will be at the top (regardless of whether operation is as a motor or as a pump). Therefore, in the event of operating as a pump the environment at high and the environment at low pressure will be at the top and the bottom, respectively, whereas in the case of operation as a motor they will be inverted.

[0022] In technical jargon, in relation to a pump, the inlet mouth 28 and the outlet mouth 29 are respectively defined as the suction and delivery whereas in relation to a motor they are normally defined as the inlet and outlet.

[0023] Also for the second wheel 22 there will be a similar path to the path 4 and a similar passage to the first channel 51 (in figure 2 they have been indicated respectively by references 95 and 96). Also for the second wheel 22 what happens for the compartments of the first wheel 21 and their interaction with the path 95 and/or the passage 96 can be repeated. The predetermined configuration of the first wheel 21 may however not be simultaneous to a configuration of the second wheel 22 in which the passage 96 places in fluid communication two consecutive compartments (as illustrated in figure 2).

[0024] The casing 3 comprises a first shim 300. The first shim 300 defines at least one cylindrical seat for housing a shaft of the first or of the second toothed wheel 21, 22.

[0025] Appropriately the first shim 300 comprises a surface that extends along a transversal plane (preferably orthogonal) to an axis of rotation of the first toothed wheel 21. Likewise, the casing 3 comprises a second shim 9. The first wheel 21 is axially interposed between the first and the second shim 300, 9. The path 95 is appropriately afforded on the first shim 9.

[0026] The casing 3 also comprises a lateral body 91 that axially surrounds the first wheel 21. The lateral body, the first and the second shim 91, 300, 9 define stator elements. In pumps the lateral body 91 is commonly defined as the pump body or motor body according to whether the machine 1 is a pump or a fluid dynamic motor.

[0027] As exemplified in figures 2, 3, 4, 6 and 7 the first channel 51 is afforded on the first shim 300. Also the path 4 is advantageously afforded on the first shim 300. Possibly the additional passage 96 is advantageously afforded on the first shim 300. The description with reference to the first channel 51 may also be repeated for the additional passage 96.

[0028] Advantageously, similar elements to the first channel 51 and/or to the path 4 and/or to the path 95 and/or to the passage 96 may also be present on the second shim 9.

[0029] As exemplified in figure 8, the first channel 51 can be afforded on the lateral body 91. Also in this case, there may be at least one additional channel (e.g. on the first shim 300).

[0030] If the volumetric machine 1 is a pump then the first channel 51 allows the first compartment 211 to be pressurised before it is overlapped with the outlet of the path 4. In this way, when such overlapping takes place the pressure in the first compartment 211 increases as an absolute value therefore the pressure difference to which the fluid is subjected at the outlet end of the path

4 is lower, thus reducing erosive phenomena.

[0031] Alternatively, if the volumetric machine 1 is a motor the first channel 51 (see figure 2) allows the first compartment 211 to be partially depressurised before it is overlapped with the inlet of the path 4 (everything that is connected to the path 4 is connected to the low pressure environment). In this way, when the first compartment 211 is overlapped with the path 4 the pressure difference between the fluid present in the first compartment 211 and the fluid present in the path 4 is lower, therefore the erosion at the mouth of the path 4 is lower.

[0032] In a particular embodiment the machine 1 allows a reversible operation, i.e. it allows correct operation in both rotation directions of the first wheel 21 (e.g. see figure 6).

[0033] For this purpose the casing 3 comprises a second channel 52 (see figure 6). In that case the first channel 51 is useful during operation in a first rotation direction of the first wheel 21 (the clockwise one in figure 6) and the second channel 52 is useful during operation in a second rotation direction of the first wheel 21 opposite the first one (the anti-clockwise one in figure 6).

[0034] In a pre-established configuration that may coincide or not with the predetermined configuration mentioned above:

- the second channel 52 places in fluid dynamic connection a third and fourth compartment 213, 214 of said first plurality 201 of compartments;
- the fourth compartment 214 is distinct from the compartments of the first plurality 201 licked by the path 4 (the third compartment 213 is instead licked by the path 4);
- the path 4 is interposed between the first and the second channel 51, 52. Should the pre-established configuration coincide with the predetermined one (as in the case of figure 6), the path 4 is interposed between the first and the fourth compartment 211, 214.

[0035] In the solution exemplified in figure 7 the first channel 51 is part of a first pair 50 of channels arranged side by side, which in said predetermined configuration place in fluid communication the first and the second compartment 211, 212.

[0036] The first channel 51 places in fluid communication the first and the second compartment 211, 212 for a rotation of the first toothed wheel 21 less than 10° (e.g. the first channel 51 could place in fluid communication the first and the second compartment 211, 212 for a rotation less than half the angular pitch of the first wheel 21). In fact the time period in which the first channel 51 allows fluid communication between the first and the second compartment 211, 212 must be relatively contained. Alternatively there would be an adaptation of the pressures of the two compartments, largely thwarting the advantages offered by the present invention.

[0037] For similar reasons, the passage section of the first channel 51 is relatively contained.

[0038] Typically, the first channel 51 has a depth lower than 1.5 millimetres. For example, in a first embodiment the path 4 extends for an amplitude comprised between 60° and 70° and the depth of the first channel 51 is less than 0.5 millimetres. In a second example embodiment the path 4 extends for an amplitude comprised between 30° and 40° and the depth of the first channel is comprised between 0.7 and 1.5 millimetres. Appropriately the first channel 51 is a pocket and has a preponderant extension direction 510 less than 20 millimetres.

[0039] To reach said predetermined configuration, the fluid communication between the second compartment 212 and the path 4 starts in phase or in advance with respect to the fluid communication between the second compartment 212 and the first compartment 211.

[0040] For example, to reach said predetermined configuration, the second compartment 212 is placed in fluid communication with the path 4 in advance with respect to the fluid communication between the second compartment 212 and the first compartment 211 (such advance could be comprised between 2° and 8°). This is, for example, the case of the first solution described above.

[0041] Alternatively, the second compartment 212 is placed in fluid communication with the first compartment 211 in phase with the path 4. As indicated above, the machine 1 may be a pump (or can however operate as a pump). In that case, the path 4 comprises a pressurisation groove of the second compartment 212. It increases the pressure of the second compartment 212 by placing it in communication with a compartment of the first plurality 201 placed downstream of said second compartment 212.

[0042] The machine 1 may be a motor or may operate both as a motor and as a pump. With reference to figure 2, in the case of operation as a motor, the path 4 comprises a groove for depressurisation the second compartment 212. The path 4 therefore allows the pressure in the second compartment 212 to be reduced by placing it in contact with a compartment placed downstream (which is at a lower pressure i.e. at the pressure available at the outlet mouth 29 of the volumetric machine 1).

[0043] Further subject matter of the present invention is an operating method of a volumetric machine having one or more of the characteristics described hereinabove.

[0044] The method comprises the step of making the first and the second toothed wheel 21, 22 rotate. In this way the fluid flows into the first plurality 201 of compartments and is moved between the inlet mouth 28 and the outlet mouth 29.

[0045] Likewise the fluid is moved by the second toothed wheel 22. This happens in the same way as in the first wheel 21.

[0046] The first and second wheel 21, 22 are counter-rotating.

[0047] In the predetermined configuration described above, the method comprises the steps of:

- making the pressure of the second compartment 212 approach that of or be uniform with one of the compartments of the first plurality 201 placed downstream of the second compartment 212 through said path 4 (such step could however take place or at least begin before reaching said predetermined configuration);
- making the pressure of the first compartment 211 approach that of the second compartment 212 through said first channel 51, in such a way that the pressure in the first compartment 211 becomes intermediate between the pressure in the second compartment 212 and the pressure of the inlet mouth 28. Appropriately (at the end of the step of making the pressure of the first compartment 211 approach that of the second compartment 212 through said first channel 51) the absolute pressure difference value between a point of the first compartment 211 and a point of the inlet mouth 28 of the machine 1 may be comprised between 30% and 70% of the absolute pressure variation value between the inlet mouth 28 and the outlet mouth 29 of the fluid.

[0048] In figure 5 the ordinates show the ratio between the pressure in the first compartment 211 and the pressure at the outlet mouth 29 as a function of the rotation angle of the first wheel 21. This graph, in the case of a pump, is to be read from left to right. In the case of operation as a motor it should be read from right to left.

[0049] Curve A shows the pressure increase in the event of a machine 1 operating as a pump in compliance with the present invention. The other curves instead relate to a machine outside the scope of the present invention. In fact, curves B and C show the pressure profile in the case in which the path 4 is absent. Curve D shows the pressure profile in the case in which the path 4 is present, but the first channel 51 is absent and it is therefore not possible to establish a priori when the compartment is pressurised.

[0050] The invention achieves important advantages.

[0051] In particular it allows the erosive phenomena that occur at one of the two ends of the path 4 to be eliminated or however reduced. With reference to figure 2 this is obtained through a first channel 51 that allows the pressure passage from the inlet mouth 28 to the outlet mouth 29 to be split into two steps. It can therefore be defined as a pre-pressurisation pocket (in the case of a pump) or a pre-depressurisation pocket (in the case of a motor). The invention as it is conceived is susceptible to numerous modifications and variants, all falling within the scope of the inventive concept characterising it. Further, all the details can be replaced with other technically-equivalent elements. In practice, all the materials used, as well as the dimensions, can be any according to requirements.

Claims

1. A volumetric machine acting on an operating fluid, comprising:

- a first toothed wheel (21) comprising a first group (210) of teeth that identify interposed between them a first plurality (201) of compartments for the operating fluid;
- a second toothed wheel (22) comprising a second group (220) of teeth intended to engage with the teeth of the first group (210);
- a casing (3) that defines a housing (30) for positioning the first and the second toothed wheel (21, 22);
- a path (4) that extends along a section of said casing (3) and that places in fluid communication at least two compartments of said first plurality (201);

said volumetric machine being a pump and/or fluid dynamic motor; **characterised in that** the casing (3) comprises at least one first channel (51) distinct from said path (4); at least in a predetermined configuration assumed by the first wheel (21):

- the first channel (51) places in fluid communication a first and a second compartment (211, 212) of said first plurality (201) which are consecutive and at least partially delimited by a same tooth of the first group (210);
- at least the first compartment (211) of the first plurality (201) being distinct from the compartments of the first plurality (201) licked by said path (4);
- said second compartment (212) being licked by the path (4);
- said first compartment (211) being placed upstream of the second compartment (212) and of the compartments of the first plurality (201) licked by said path (4).

2. The machine according to claim 1, **characterised in that** the casing (3) comprises a first shim (300) on which said first channel (51) is afforded.

3. The machine according to claim 1 or 2, **characterised in that** said first channel (51) has a depth of less than 1.5 millimetres.

4. The machine according to any one of the preceding claims, **characterised in that** the path (4) extends along an arc of circumference.

5. The machine according to any one of the preceding claims, **characterised in that** it allows a reversible operation in both directions of rotation of the first toothed wheel (21), said casing (3) comprising a sec-

ond channel (52);
in a pre-established configuration that may coincide or not with said predetermined configuration:

- the second channel (52) places in fluid dynamic connection a third and fourth compartment (213, 214) of said first plurality (201) of compartments;
- the fourth compartment (214) is distinct from the compartments of the first plurality (201) licked by the path (4);
- the path (4) is interposed between the first and the second channel (51, 52).

6. The machine according to any one of the preceding claims, **characterised in that** the first channel (51) is part of a first pair (50) of channels arranged side by side, which in the predetermined configuration place in fluid communication the first and the second compartment (211, 212).

7. The machine according to any one of the preceding claims, **characterised in that** the first channel (51) places in fluid communication the first and the second compartment (211, 212) for a rotation of the first toothed wheel (21) less than 10°.

8. The machine according to any one of the preceding claims, **characterised in that** it is:

- a pump, said path (4) comprising a pressurisation groove of the second compartment (212) which increases the pressure of the second compartment (212) placing it in communication with a compartment of the first plurality (201) placed downstream of said second compartment (212); or
- a motor, said path (4) comprising a depressurisation groove of the second compartment (212) which permits the pressure of the second compartment (212) to be reduced by putting it in contact with a compartment of the first plurality which is placed downstream and is located at a lower pressure.

9. The machine according to any one of the preceding claims, **characterised in that** the first channel (51) is a pocket and has a predominant extension direction (510) of less than 20 millimetres.

10. An operating method of a volumetric machine according to any one of claims 1 to 9, comprising the step of making the first and the second toothed wheel (21, 22) turn, making the fluid flow into the first plurality (201) of compartments and moving it between an inlet mouth (28) in the machine (1) and an outlet mouth (39) from the machine (1);
in said predetermined configuration, the method comprises the step of making the pressure of the first compartment (211) approach that of the second compartment (212) through said first channel (51), in such a way that the pressure in the first compartment (211) becomes intermediate between the pressure in the second compartment (212) and the pressure of the inlet mouth (28).

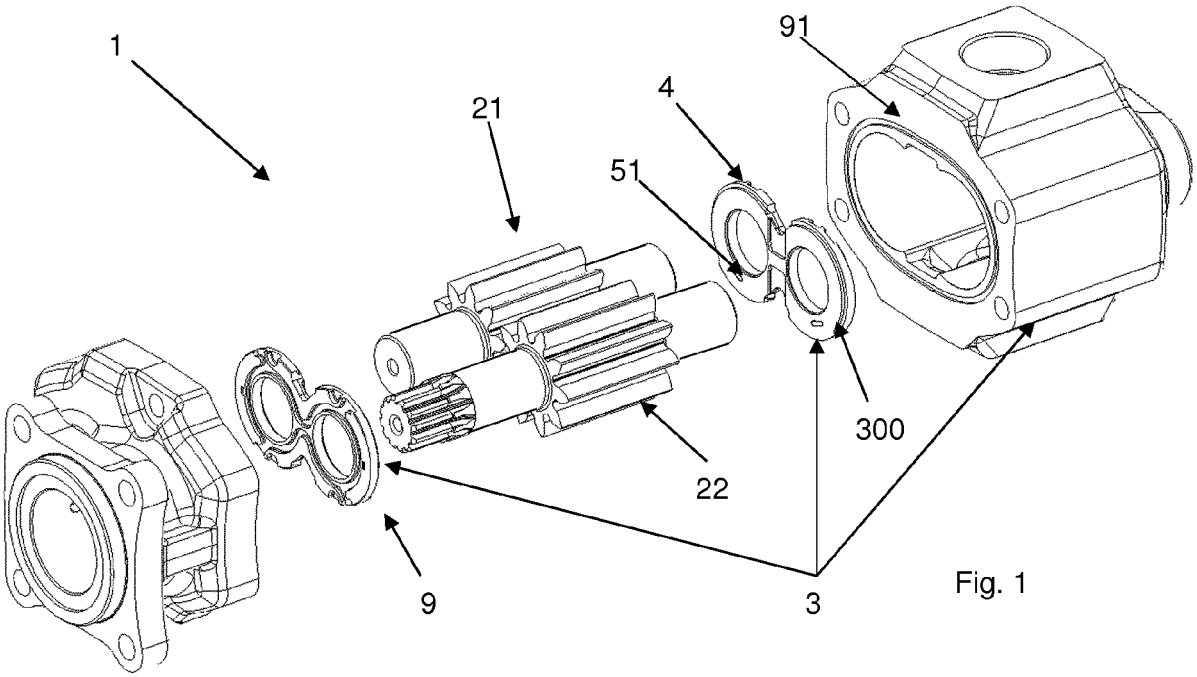


Fig. 1

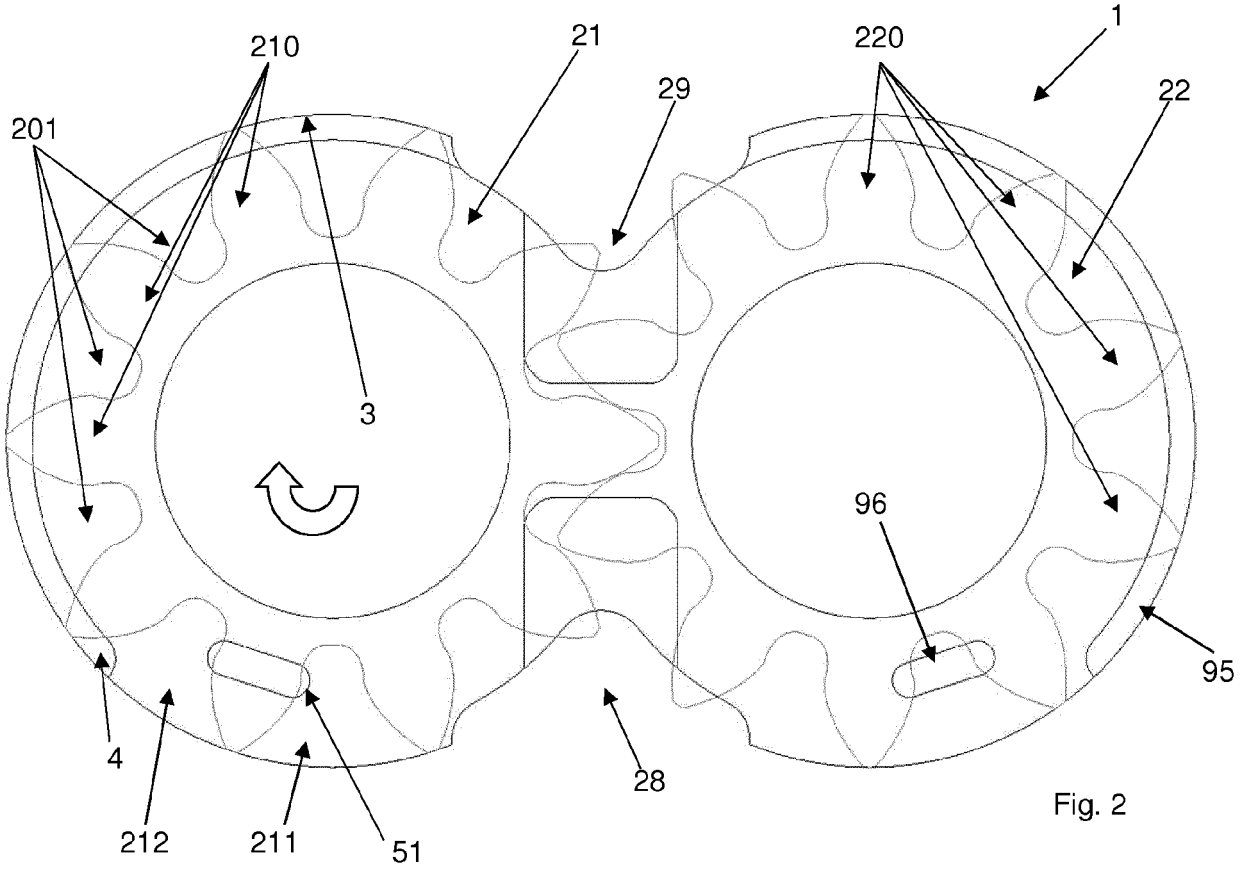


Fig. 2

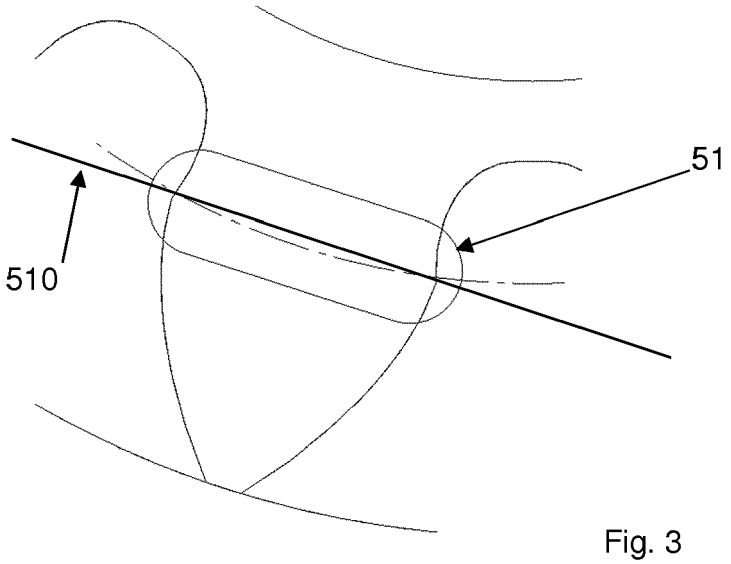


Fig. 3

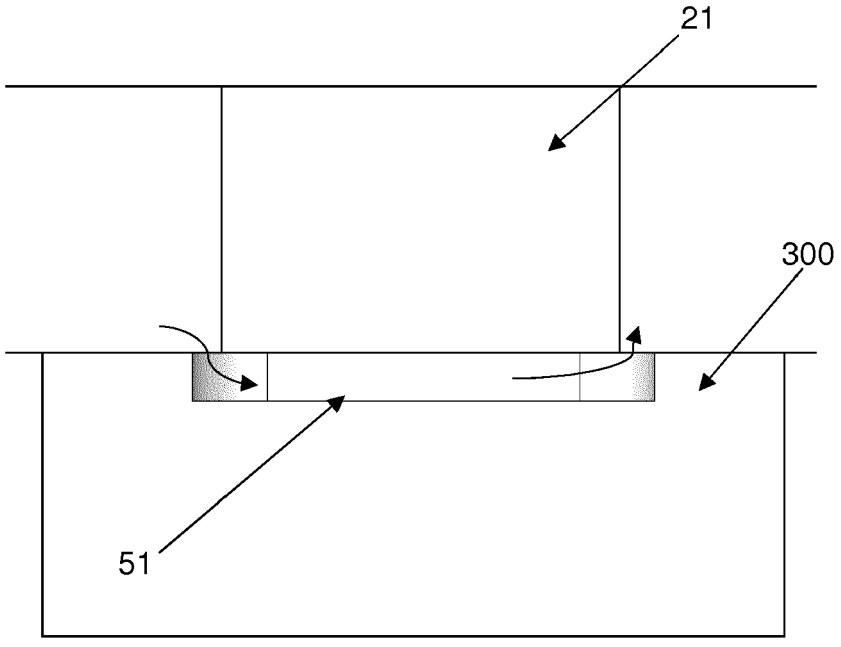


Fig. 4

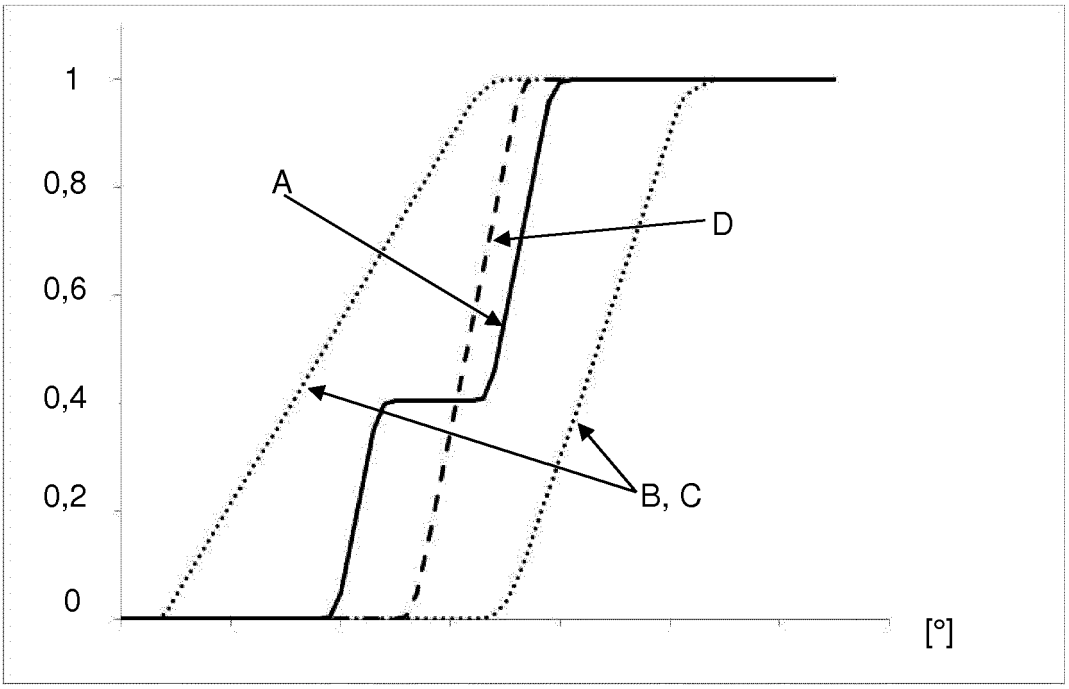


Fig. 5

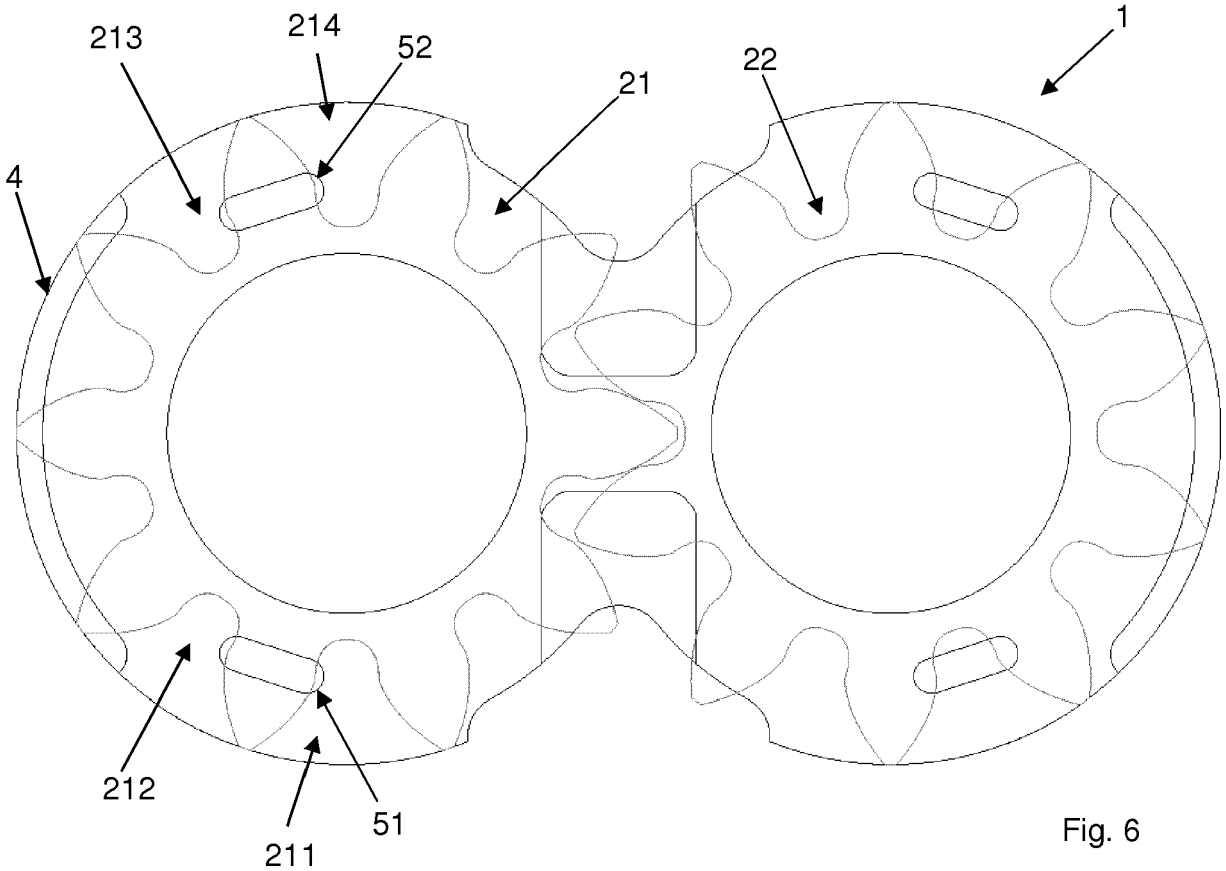


Fig. 6

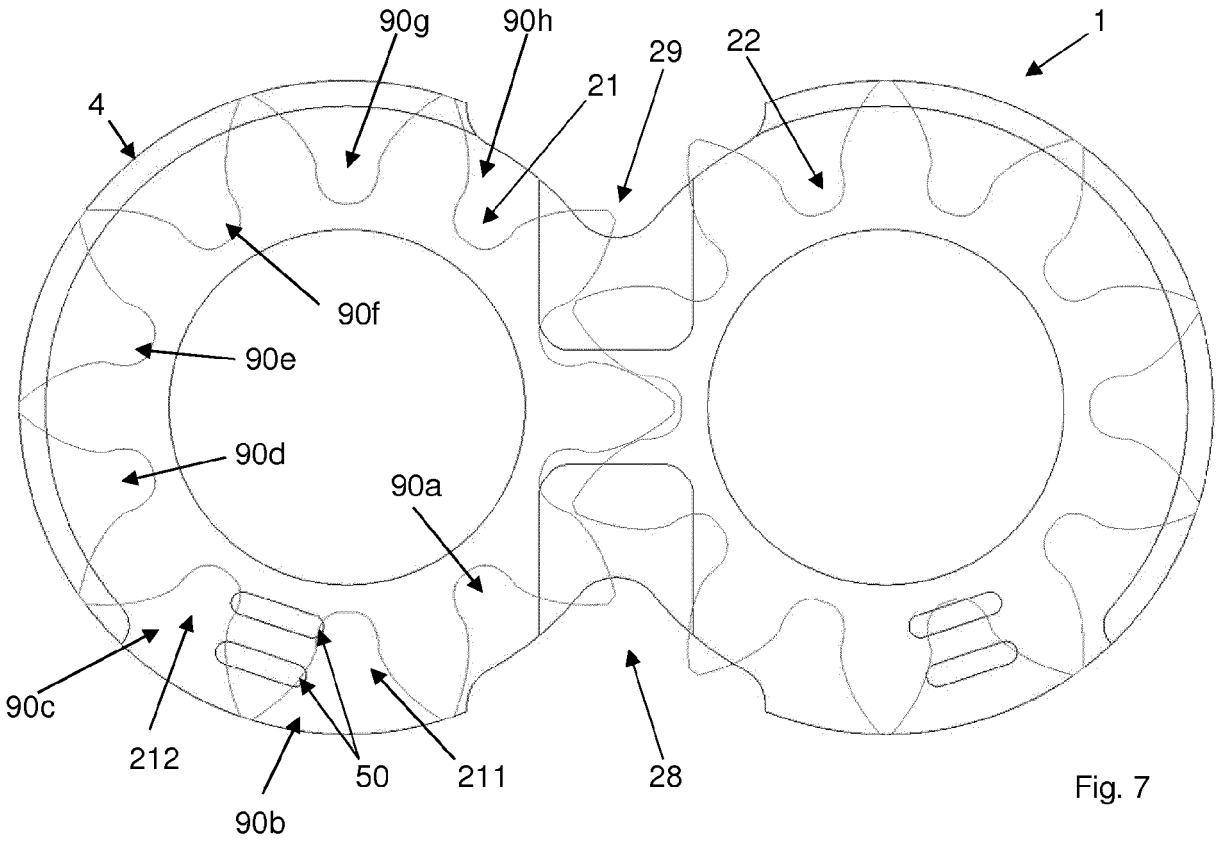

90g
90h
29
22
1
21
4
90f
90e
90d
90a
90c
212
50
211
28
90b

Fig. 7

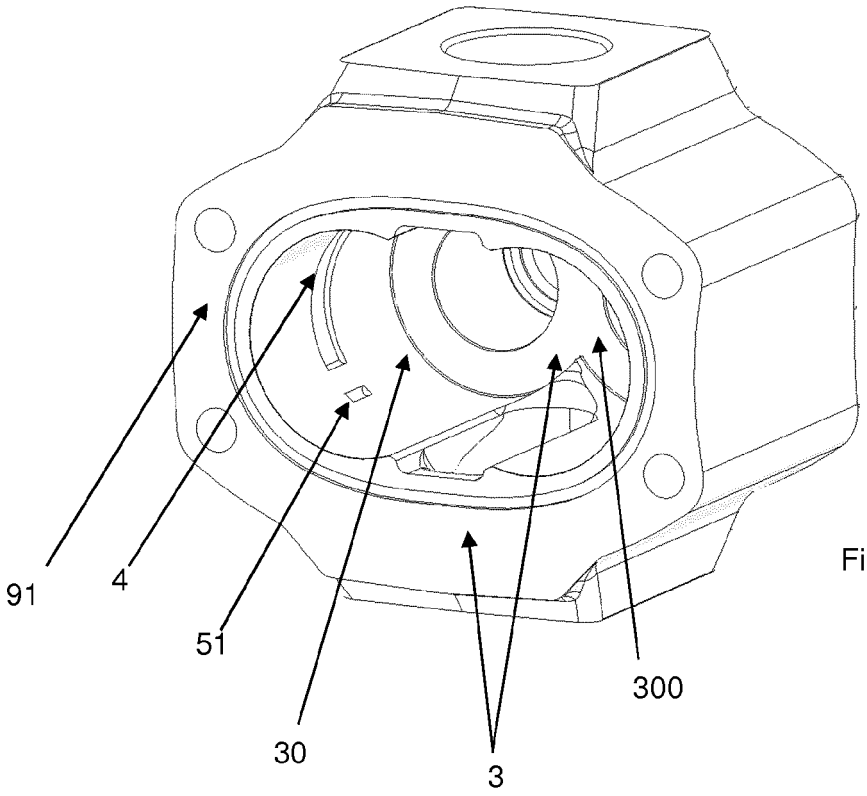

91
4
51
30
3
300

Fig. 8

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EUROPEAN SEARCH REPORT

Application Number
EP 18 15 1079

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 A	GB 1 224 566 A (KOEHRING CO [US]) 10 March 1971 (1971-03-10) * page 3, line 65 - page 4, line 5; figure 4 * -----	1-4,6-10 5	INV. F04C2/18
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TECHNICAL FIELDS SEARCHED (IPC)
F04C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	26 March 2018	Grilli, Muzio

CATEGORY OF CITED DOCUMENTS

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