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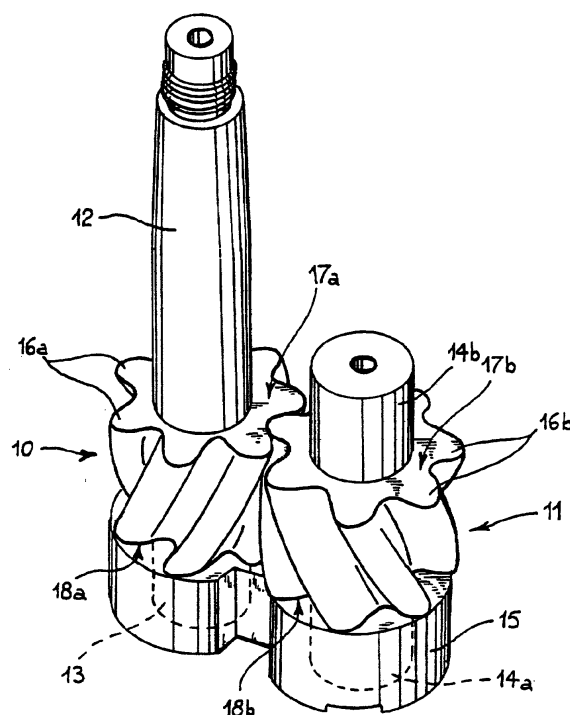
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(54) **A positive-displacement rotary pump with helical rotors**

(57) A positive-displacement rotary pump comprises a pair of meshing rotors or gears (10, 11), that is, a driving rotor or gear and a driven rotor or gear, respectively, enclosed in a casing with a delivery opening and an intake opening for a fluid. The gears (10, 11) comprise a plurality of teeth (16a, 16b) meshing without encapsulation and at the same time defining sets of helical teeth with a face overlap substantially equal to or close to unity. The combination of a profile of the teeth which prevents encapsulation and of the helical arrangement of the teeth reduces ripple and the noise resulting therefrom when the pump is in operation.

FIG.1



Description

[0001] The present invention relates to the field of positive-displacement rotary pumps. Rotary pumps of various types are known, amongst which gear pumps, lobe pumps and screw pumps are mentioned.

[0002] Gear pumps are generally constituted by two gears with straight teeth of which one, known as the driving gear, is connected to a drive shaft and rotates the other gear, which is known as the driven gear. A disadvantage noticed particularly in the above-mentioned gear pumps is the risk of the fluid pumped being encapsulated and compressed in the spaces enclosed between the profiles of the teeth in the meshing region and giving rise to dangerous local stress peaks, especially when the fluid is incompressible. To prevent the above-mentioned problem occurring, it is necessary to adopt particular construction designs consisting, for example, in the formation of recesses in the side walls or head elements of the pump, enabling the fluid trapped to escape towards the delivery or the intake. The problem, which is discussed in greater detail below, resulting from the phenomenon of irregularity or "ripple" in the transfer of the fluid, is also known. These problems cause noisiness in the operation of known pumps. An investigation of the above-mentioned problems which are connected with the design of gear pumps is dealt with in "C. Bonacini, Sulla portata delle pompe ad ingranaggi, L'ingegnere, 1961 n. 9" (On the capacity of gear pumps, The Engineer, 1961, No. 9).

[0003] Lobe pumps are also constituted by at least two rotors with mating profiles which rotate inside a fixed casing. Lobe pumps with mating external profiles have the advantage over gear pumps that they have greater displacement for a given space occupied, but they require external devices, for example, an additional pair of gears, to synchronize the movement of the rotors. Although lobe pumps with mating internal profiles do not require external synchronization devices, they have small specific displacement and generally mediocre volumetric output.

[0004] Screw pumps implement the same liquid-transfer system in axial and peripheral directions as is implemented by the above-mentioned gear pumps purely in a peripheral direction. Although they have good flow-regularity characteristics, screw pumps generally have disadvantages similar to those of gear pumps, particularly with regard to the risk of the encapsulation of fluid.

[0005] With specific reference to the encapsulation problem, a solution with regard to application in the field of lobe pumps, is described in the Applicant's patent document IT-BO95A000095, the content of which is incorporated herein in full by reference so as to provide a person skilled in the art with the details of the design and the specific configuration of the teeth of the rotors described in this prior document. This solution relates in particular but not exclusively to a configuration of the profiles of the rotor teeth of a Roots compressor such that, except for manufacturing play and tolerances, in each relative angular position of the rotors, at least one gen-

eratrix of the first rotor is substantially in contact with only one generatrix of the second rotor. This configuration of the rotor profiles prevents the formation of encapsulated spaces between the rotors and the consequent disadvantages which may result therefrom. The solution referred to above does not, however, solve the main problem of lobe pumps, that is, the need to provide an external system for driving and synchronizing the two rotors.

[0006] In any case, as indicated above, all of the above-mentioned solutions of the prior art have the common problem consisting of noisiness in operation produced by instantaneous oscillations of the flow-rate over time, better known as ripple noise. The above-mentioned oscillations generate a pulsating wave which is transmitted through the fluid to the surrounding environment and, in particular, to the walls of the pump, to the pipes, and to the delivery ducts. The noise produced may even reach unpredictable levels if the above-mentioned members come into resonance with the oscillation or ripple frequency.

[0007] A series of investigations and tests has shown that these oscillations are due intrinsically to the configuration of the rotors or gears of the above-mentioned pumps which, at successive stages of their meshing, produce a discontinuity in the volume variation which brings about the transfer of the fluid from the intake to the delivery. In other words, the ripple is due to the discontinuity in the variation of this volume with respect to time or, rather, with respect to the relative angular positions of the rotors.

[0008] A solution proposed for solving the problem indicated above is that of providing two identical positive-displacement rotary pumps in parallel in a manner such that the oscillations generated by one are in phase opposition with and hence at least partially compensated by the oscillations of the other. Naturally, the main disadvantage of this solution is its particular structural complexity and, more generally, its high cost.

[0009] The object of the present invention is to provide a positive-displacement rotary pump which overcomes the disadvantages of the prior art and, in particular, which considerably reduces ripple noise without this leading to an increase in cost and in structural complexity in comparison with more conventional screw or gear pumps. A further object of the invention is to provide a pump which has good leaktightness characteristics, which is easy and inexpensive to produce and to maintain, and which has good reliability over time whilst, at the same time, eliminating encapsulation problems.

[0010] To achieve the objects indicated above, the subject of the invention is a positive-displacement pump comprising a pair of meshing rotors or gears, that is, a driving rotor or gear and a driven rotor or gear, respectively, enclosed in a casing with a delivery opening and an intake opening for a fluid, characterized in that the gears comprise a plurality of teeth meshing without encapsulation and at the same defining helical sets of teeth with a face overlap substantially equal to or close to unity.

[0011] Further characteristics and advantages of the invention will become clear from the following detailed description, given purely by way of non-limiting example with reference to the appended drawings, in which:

Figure 1 shows, in perspective, a pair of meshing rotors or gears of a pump formed in accordance with the present invention,

Figure 2 is a schematic longitudinal section through the pair of rotors of Figure 1 showing, in particular, the system for compensating for the axial thrusts of the pair of gears,

Figure 3 is a cross-section of the pair of rotors of Figure 1 in a first angular meshing position,

Figure 4 is a section similar to that of Figure 2, showing the pair of rotors in a second angular meshing position, and

Figure 5 shows the pair of rotors of Figure 2 in a third meshing position.

[0012] With reference now to Figures 1 and 2, a positive-displacement rotary pump comprises a first gear or rotor 10 and a second gear or rotor 11. The first gear 10 is connected integrally or by means of a fixing of a type generally known in the art, to a drive shaft 12 which takes the drive from a drive member (not shown) when the pump is in use. The second gear 11 meshes with the first gear and is rotated thereby in use. Both of the gears 10, 11 have shanks or shafts 13, 14a, 14b which, in similar manner to the drive shaft 12, are mounted rotatably in a leaktight manner in head elements 15, only one of which is shown in Figure 1 for clarity of illustration. As is well known in the field of rotary pumps, the gears 10, 11 are enclosed in a casing (not shown) having an intake opening and a delivery opening for the fluid to be pumped.

[0013] Each gear 10, 11 has a series of peripheral teeth 16a, 16b with identical profiles, preferably produced in accordance with the teachings of patent document IT-BO95A000095, which is incorporated herein by reference, and in any case such as to ensure an absence of fluid-encapsulation areas for each relative angular position of the gears. Although other gear profiles which can satisfy the above-mentioned requirement for an absence of encapsulation, particularly those used in lobe pumps, are known, it is considered that the profile of the Applicant's above-mentioned patent document constitutes the preferable solution for the present invention since, for a given space occupied, it enables teeth of greater height to be produced and hence greater flow-rates to be achieved. Moreover, in the portion in the vicinity of the pitch circle, in the region in which the drive is transmitted from the driving gear 10 to the driven gear 11, the profile preferably adopted is, in cross-section, an involute portion such as to render the profile satisfactorily insensitive

to variations in the interaxial spacing between the two gears 10, 11. Finally, the profile preferably selected is easy to manufacture since, in contrast, for example, with "cycloidal" profiles, it does not have portions with radii of curvature tending to zero, particularly in the vicinity of the pitch circle.

[0014] The number of teeth of each gear 10, 11 in relation to the helix angle is such that meshing and driving of the driven gear 11 by the driving gear 10 can be ensured in any angular position without, however, excessively limiting the space occupied by the teeth inside the pump casing and hence the capacity of the pump. In the preferred embodiment shown in the drawings, each gear 10, 11 has seven teeth 16a, 16b but, naturally, the number of teeth may vary according to the specific design details in embodiments of the present invention, particularly according to the dimensions and to the interaxial spacing of the rotary pump.

[0015] The teeth 16a, 16b extend helically along the height of each gear 10, 11 with a face overlap substantially equal to or close to unity, that is - in other words - with an axial pitch between two successive teeth equal to or close to the height of the gear in the direction of its axis of rotation. By virtue of this configuration, the cross-section of a tooth 16a or 16b at the level of one end face 17a, 17b of the respective gear 10, 11 is substantially aligned - along an axis parallel to the axis of rotation of the gear - with the cross-section of an adjacent tooth 16a, 16b at the level of the other end face 18a, 18b of the respective gear 10, 11.

[0016] Figure 2 shows in detail a solution for compensating for the axial thrusts which, as is known, are generated by the pair of helical gears 10, 11 and by the spatial configuration of the teeth which are exposed to pressure variation. In particular, the ends of the shafts or shanks 13, 14a bear against a pair of respective abutment pins 19, 20 which are mounted so as to be slidable axially in a leaktight manner in respective axial housings 21, 22 formed in a flange 23. The ends of the abutment pins 19, 20 remote from the shafts or shanks 13, 14a face a common chamber 24 which is formed in a closure plate 25 and, in use, is preferably in communication with the delivery of the rotary pump. By acting on the abutment pins 19, 20, the pressurized fluid which comes to occupy the chamber 24 thus opposes the axial thrust generated by the gears 10, 11. If, as is preferable, the pressure in the chamber 24 is generated by the pump itself, the balancing of the axial thrusts is regulated automatically and maintains its effectiveness with variations in pressure.

[0017] Figures 3 to 5 show, in cross-section, relative to the axis of rotation of the gears 10, 11, the positions adopted by the teeth 16a, 16b at successive moments of meshing. It is clear that no closed spaces are formed between the sets of teeth of the gears 10, 11 at any time, particularly in the position shown in Figure 4 which, in pumps with conventional gears, in contrast, leads to the problematic generation of such a closed space, defined by the sides of the teeth which come into contact along

two pitch lines.

[0018] However, by virtue of the configuration of the gears 10, 11, which, as a whole, defines a pair of helical gears with a face overlap equal to or close to unity, Figures 3 to 5 are also representative of the configurations adopted by the teeth 16a, 16b at the same moment in time but in different transverse planes identified along the height of the gears 10, 11. In other words, if cross-sections are taken progressively along the entire face height of the pair of gears, all of the possible configurations of meshing between the gears are found and all of these configurations can be utilized by virtue of the fact that there is no discontinuity in the meshing at the roots of the teeth, that is, there is no encapsulation. This fact, which is of fundamental importance for the present invention, leads to the result that, when the pump is in operation, no discontinuities arise in the volume variation which brings about the transfer of the fluid from the intake to the delivery, with the consequence that, except for working tolerances and manufacturing imperfections of the gears 10, 11, the oscillations of the flow-rate of fluid are cancelled out or at least reduced to a significant extent in comparison with what can be achieved with conventional pumps. A result of this type cannot be achieved simply by the use of helical teeth in conventional gear pumps since the production of a pair of helical gears with a face overlap which is equal to unity or in any case is quite exaggerated would involve the risk of a passage-way being opened between the intake and the delivery for particular angular positions of the teeth, with a consequent unacceptable drop in the output and performance of the pump. Moreover, in conventional gear pumps, there is a portion of the tooth with meshing discontinuity, in which the head of one tooth is detached from the root of the tooth meshing therewith so that there would be ripple even if a face overlap close to unity could be achieved so as to solve the problem of the passage-way between the output and intake.

[0019] The particular combination of the present invention, consisting of the combined use of helical teeth and encapsulation-free tooth profiles permits the production of positive-displacement rotary pumps which are decidedly improved in comparison with previously known pumps, particularly with regard to the resulting reduction in ripple and in noise.

[0020] Naturally, the principle of the invention remaining the same, the forms of embodiment and details of construction may be varied widely with respect to those described and illustrated, without thereby departing from the scope of the present invention.

Claims

1. A positive-displacement rotary pump comprising a pair of meshing rotors or gears (10, 11), that is, a driving rotor or gear and a driven rotor or gear, respectively, enclosed in a casing with a delivery open-

ing and an intake opening for a fluid, wherein the gears (10, 11) comprise a plurality of teeth (16a, 16b) meshing without encapsulation and at the same time defining sets of helical teeth with a face overlap substantially equal to or close to unity, **characterized in that** it comprises an axial-thrust compensation system, comprising axial thrust means (19, 20) which are subject to a fluid pressure in use and which act on the shafts (13, 14a) to exert different axial thrusts on each one of the two shafts (13, 14a), respectively.

2. A positive-displacement rotary pump according to Claim 1, **characterized in that** the compensation system comprises a common fluid-pressure chamber (24).
3. A positive-displacement rotary pump according to Claim 2, **characterized in that** the fluid-pressure chamber (24) is put into communication with the delivery of the pump.
4. A positive-displacement rotary pump according to Claim 1, **characterized in that** the ends of the shafts (13, 14a) bear against a pair of abutment pins (19, 20).
5. A positive-displacement rotary pump according to Claim 2 and Claim 4, **characterized in that** the ends of the abutment pins (19, 20) remote from the shafts (13, 14a) both face the common fluid-pressure chamber (24).
6. A positive-displacement rotary pump according to Claim 4 or 5, **characterized in that** the abutment pins (19, 20) are mounted so as to be slidable axially in a leaktight manner in respective axial housings (21, 22) formed in a flange (23).
7. A positive-displacement rotary pump according to any one of the preceding Claims, **characterized in that** the teeth (16a, 16b) have, in cross-section, a profile defined by parametric curves, particularly in accordance with the teachings of patent document IT-BO95A000095.

FIG.1

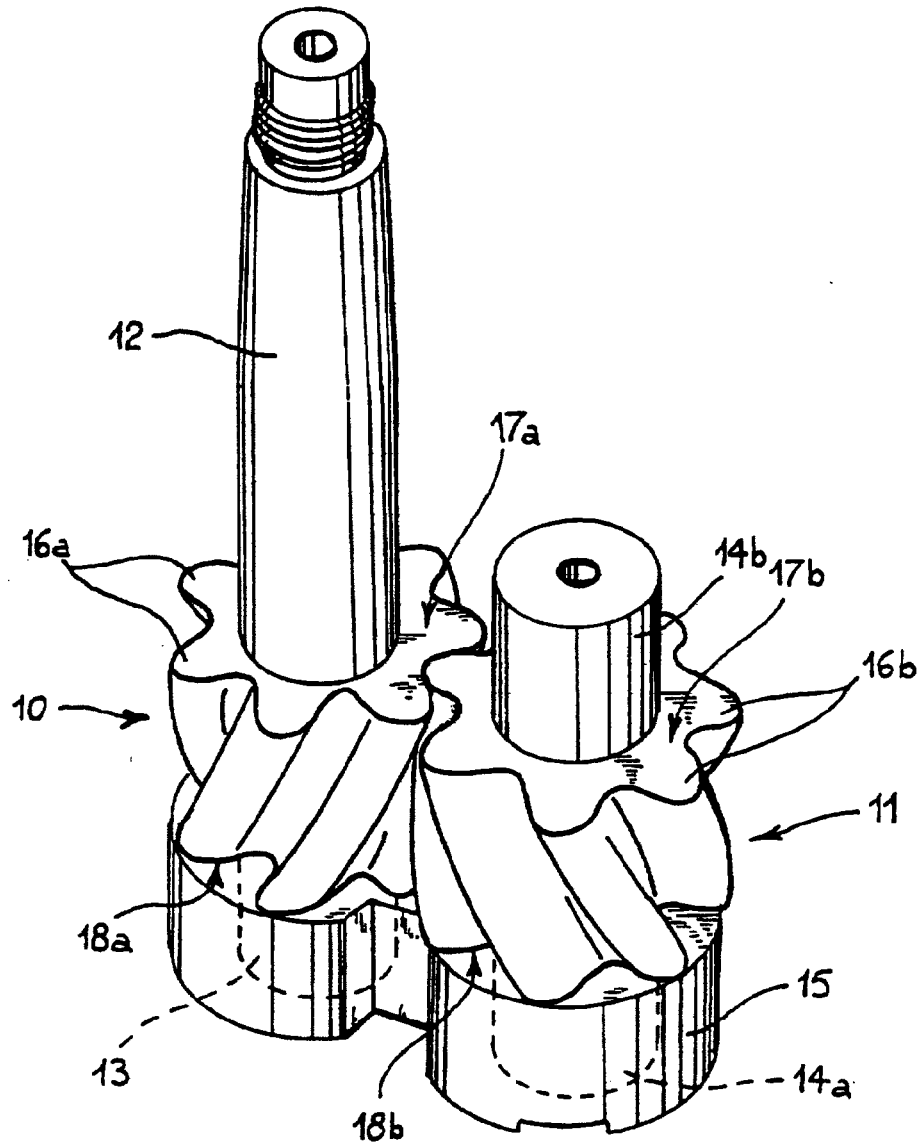


FIG.2

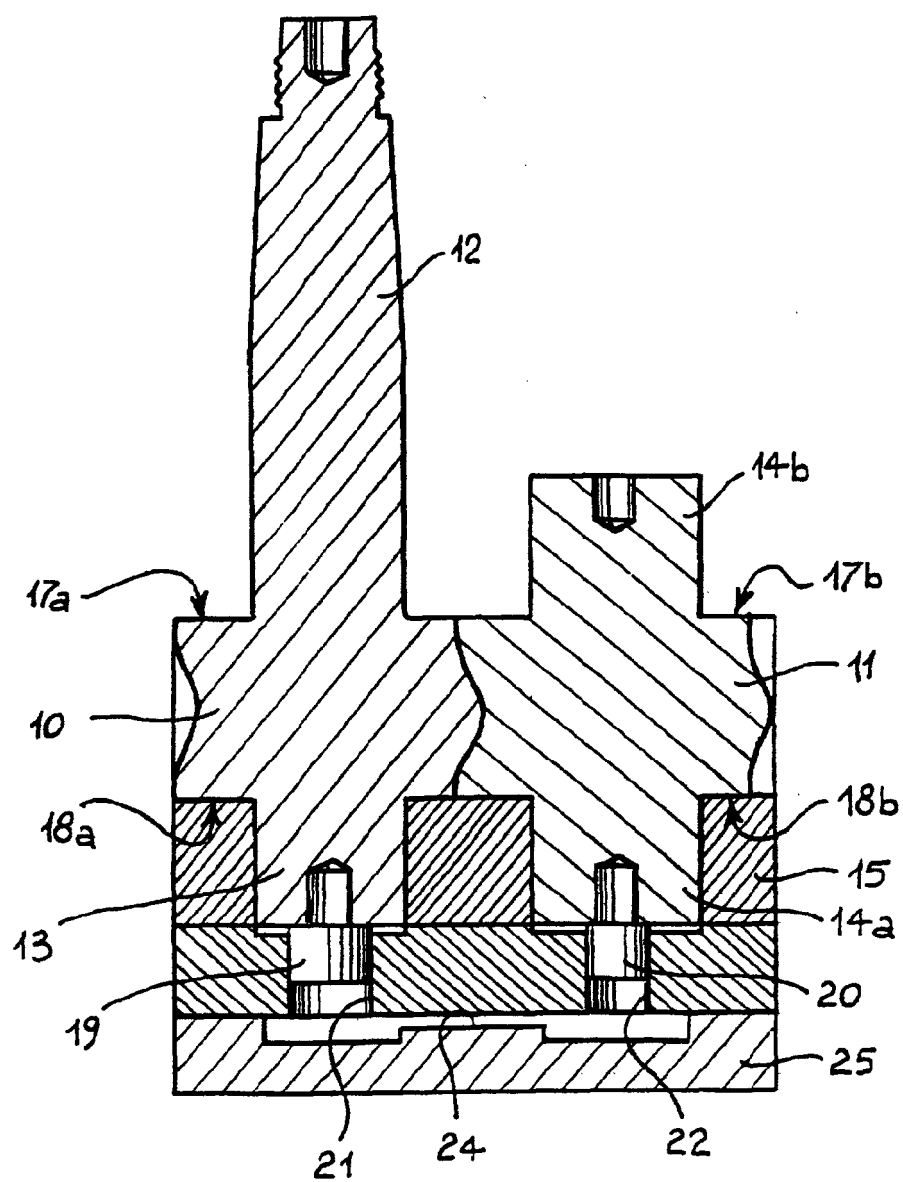


FIG.3

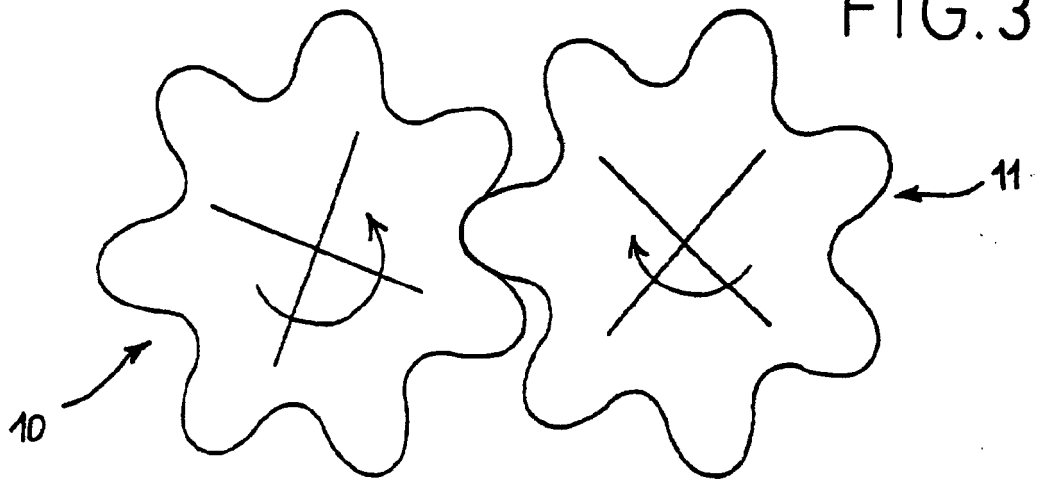


FIG.4

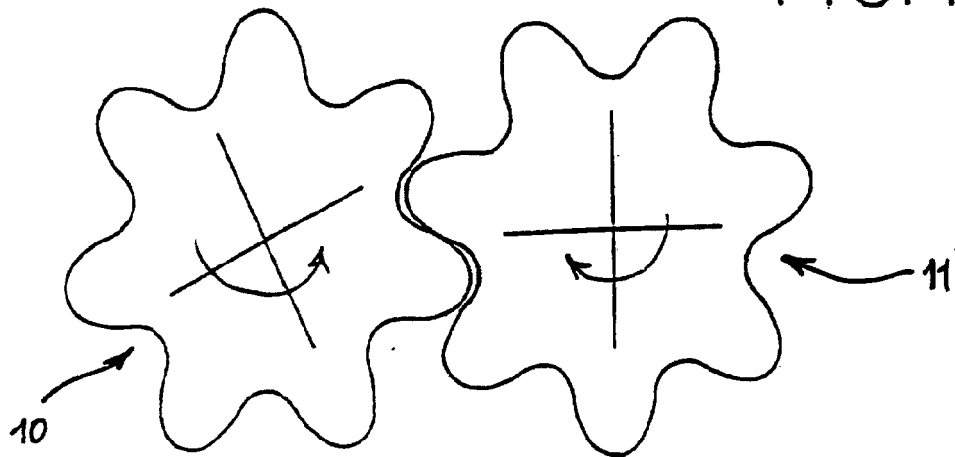
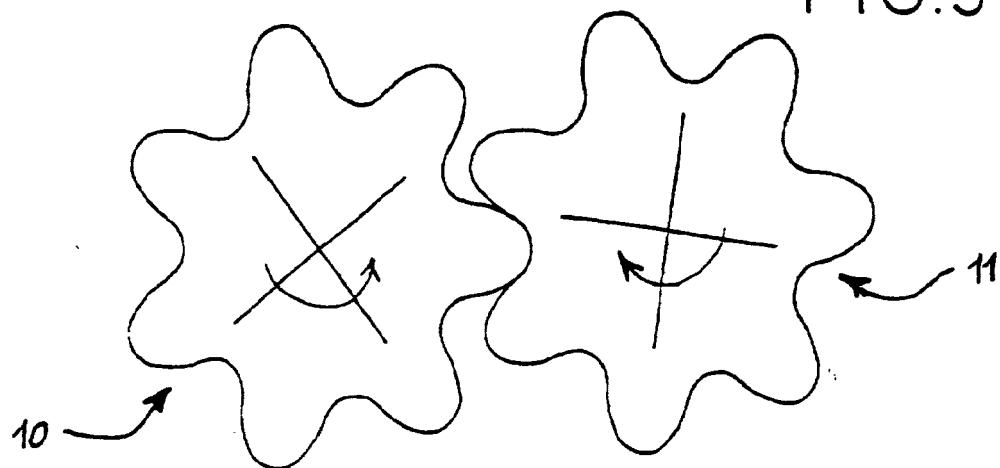


FIG.5



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- IT BO950095 A [0005] [0013]

Non-patent literature cited in the description

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