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(54) Two-rotor rotary engine

(57) The present application relates to an internal combustion rotary engine and the related operation method, comprising a case and two rotors; the rotors are reciprocally counter - rotating and intermeshing in an operative condition and are shaped in order to form, at least between the ignition step of the mixture supplying the engine and the expansion step of the same mixture, a chamber composed of side walls substantially exclusively belonging to the rotors. The engine is further provided with proper means for the fuel inflow, for the air inflow and for the ignition and the outflow of the mixture. The ignition means are positioned so that to ignite the mixture before or during the taking form of the first chamber.

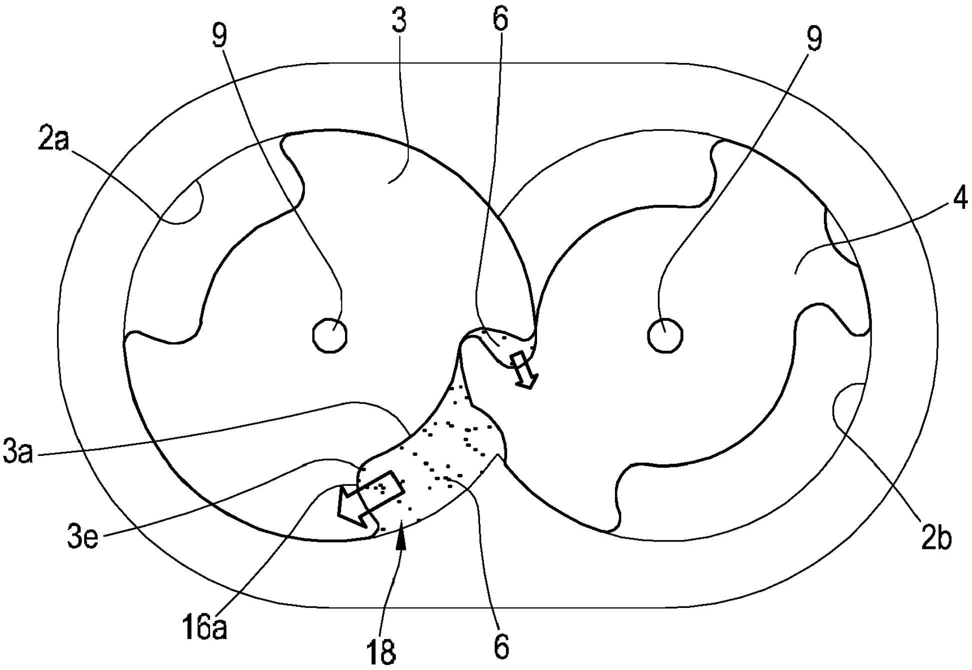

Fig. 4

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Description

[0001] The present invention applies to the field of the internal combustion rotary engines, of the typology supplied with a fuel mixture in order to carry out at least one intake step/formation step of the mixture, one compression step of the mixture, and one expansion step of the mixture following the respective ignition (which can also start immediately before the maximum compression), in addition to an exhaust step of the combustion mixture (gas), and in particular applies to the rotary engines having two distinct rotors.

[0002] Rotary engines having a single rotor are known in the art, among whom the engine known in the art as "Wankel" engine. In such an engine, a single rotor having an almost triangular shape (known in geometry as "Reuleaux triangle") rotates inside a case having circular section. The gap between the "triangle" sides and the case forms three movable chambers for a fuel mixture. Inflow and outflow ports for the mixture and mixture ignition means are placed along the case, in order to carry out the four steps of the conventional engine.

[0003] Engines having several rotors are also known, generally with two counter - rotating and intermeshing rotors rotating inside a respective case. The gaps which take form between rotor and rotor and between rotors and case define movable chambers for a fuel mixture which undergoes the afore shortly mentioned steps.

[0004] However, multi-rotor engines of the known art did not show a good trade-off between operative efficiency and manufacturing easiness such to allow a diffused use thereof.

[0005] Object of the present invention is to realize a two - rotor rotary engine having a suitable efficiency while holding a given manufacturing easiness.

[0006] Such an object is achieved by an engine having configuration according to claim 1. An operation method of the engine is described in claim 14.

[0007] Preferred aspects are suggested in the respective dependent claims.

[0008] In particular, an engine according to the present invention comprises a case, a first rotor and a second rotor. The rotors are reciprocally counter - rotating and intermeshing in an operative condition, so as to define an intake step/formation step of a fuel mixture, a compression step, an expansion step following the ignition of the mixture and an exhaust step of the combusted mixture (combustion gases). The engine further comprises ignition means for igniting the mixture, air inflow means and fuel inflow means. Outflow means are further provided for outflowing the combusted mixture. According to the invention the rotors are shaped so as to form, at least between the mixture ignition and the expansion step of the mixture, a first chamber composed of side walls substantially exclusively belonging to the rotors themselves and wherein the upper and lower walls typically belong to the case (housing box) of the engine. The ignition means are positioned so as to ignite the mixture before (at worst during) the taking form of the mentioned chamber.

[0009] It has to be noted that with the terminology "mixture expansion" the expansion of the fluid present inside the engine during the combustion step thereof is meant, whereby in this phase the "mixture" is not to be intended as the simple combining of fuel and air, but at least partially as comprising the combustion products thereof (combustion gases).

[0010] The terminologies "side wall" and "upper/lower wall" are apparent for a field technician.

[0011] In particular, by "side wall" a chamber wall is meant which is substantially parallel to the rotation axis of a rotor, whereas by "upper wall" or "lower wall" a surface of the chamber arranged substantially perpendicularly to the rotation axis of a rotor is intended.

[0012] Thanks to the present invention, the compression step of the mixture is particularly effectively controlled by the rotors' outline.

[0013] In addition during the compression step, that is to say during that step immediately preceding the expansion step of the burning mixture, the side walls of the chamber, on which the fluid acts, essentially belong to the two rotors thereby increasing the efficiency of the thrust of the burning mixture during the expansion step, since the burning mixture, at least in the first moments of this latter step, will mainly act on the rotor walls as thrusting onto the same, without ineffectively acting on a large area belonging to the fixed walls of the engine case.

[0014] In addition, by positioning the ignition means so as to ignite the mixture before, or at the latest during, the taking form of the mentioned chamber, the ignition of the mixture can be brought forward with respect to the condition of maximum compression of the same, corresponding to the moment the mixture is contained inside such a chamber.

[0015] This allows effectively taking advantage from the rotation of the two rotors, in particular by allowing the expanding mixture to be used to thrust both the rotors. Thanks to this, a complete engine cycle (intake, compression, combustion and expansion, exhaust) can be carried out in a single revolution of both the rotors. Furthermore, according to a preferred aspect of the invention, during at least part of the expansion step of the mixture (or better of the burning mixture), the rotors define a second chamber comprising one or more thrust shaped surfaces on at least one rotor to make rotate the latter.

[0016] In particular, in the portion of (at least) one rotor defining a portion of the chamber perimeter, the rotor has a portion shaped so as to operatively couple with the pressure of the expanding mixture, in order to create a torque on the rotor.

[0017] Thanks to this, the sum of the momenta acting on the rotor, in particular of the momenta caused by the thrust provided by the mixture expanding on the rotor, is non-null.

[0018] According to an aspect of the invention, during the expansion also a third chamber takes form having thrust shaped surfaces similar to the second chamber.

[0019] Typically, the second chamber has thrust shaped surfaces on a first rotor, whereas the third chamber has thrust shaped surfaces on the remaining rotor.

[0020] Preferably the thrust shaped surfaces have a C shape, or anyway an at least partially concave shape.

[0021] According to a further aspect of the invention, the first and the second rotor have a central portion substantially circular in sectional view. The circular portion is provided with two head elements protruding from the circular portion at opposing areas of a diameter of the same. The head portions have an at least partially circular outer outline and, in particular, the circular portion of the first rotor and the head portions of the second rotor define, in an operative condition, chambers having variable size depending on the relative rotation between first and second rotor and vice versa.

[0022] The central portions of the two rotors preferably have diameters equal one to another. However, the first rotor, that is to say the rotor placed at the ignition means and the rotation means, has a circular outline smaller than the second rotor. In other words, the second rotor has a central portion defined by two arcs of a circle having larger width than the width of the corresponding arcs of the first rotor. In a preferred embodiment, the arcs of the central portion of the second rotor have a width of about 150% of the width of the arcs in the central portion of the first rotor.

[0023] As a result, the second rotor is "slimmer" than the first rotor. Accordingly the chambers taking form between the second rotor and the respective seat are generically larger than the chambers taking form between the first rotor and the respective seat.

[0024] The rotors' shape according to the present invention has shown to be advantageous since it allows an effective distinction and definition of the chambers in order to house the mixture and define the various steps of the engine.

[0025] According to an aspect of the invention, the ignition means are arranged in a fluidic communication with a fourth chamber arranged between the central portion of the first rotor and the case. The mentioned fourth chamber takes form when the central portion of the second rotor is operatively coupled with a head portion of the first rotor.

[0026] Furthermore, a fifth chamber takes form between first and second rotors, when a head portion of the second rotor is operatively coupled with the central portion of the first rotor.

[0027] Preferably, such a fifth chamber is in its own turn divided between a first and a second sub - chambers. The two sub - chambers are fluidically connected by means of a small-section portion.

[0028] According to a particular aspect of the invention, the first sub - chamber has side walls substantially exclusively belonging to the rotors, whereby the above described second chamber and the first sub - chamber of the fifth chamber coincide.

[0029] Since such a concurrence may not subsist, from now on the two chambers will be identified, depending on their function, by the two distinct references, that is to say "second chamber" and "first sub - chamber" of the fifth chamber.

[0030] Second injection means are fluidically connected with such a fifth chamber, and preferably with the second sub - chamber of such a fifth chamber.

[0031] Forced ventilation means can bring air into said case.

[0032] Referring to the figures, an exemplary and not limitative embodiment of the present invention is now presented, in which:

- figures 1 - 5 are front sectional views of an engine according to the present invention in different and consecutive operative steps;
- figure 6 is a plan view of the engine of figures 1 - 5;
- figure 7 is an enlargement of a detail of figure 3;
- figures 8A and 8B are detailed views of the rotors of the engine of figures 1 - 5.

[0033] Referring to the figures a rotary engine 1 is shown, according to a particular embodiment of the present invention, comprising a case 2, a first rotor 3, a second rotor 4, ignition means 5 for igniting a mixture 6, air inflow means 13a, 13b, fuel inflow means 7a, 7b and outflow means 12a, 12b for outflowing the mixture 6 once it has been essentially combusted (exhaust gases).

[0034] According to a particular aspect of the invention, referring particularly to figures 8A and 8B, the rotors 3, 4 each have one central portion 3a, 4a having a substantially circular outline. Each circular portion 3a, 4a is provided with two head portions 3b, 3c and 4b, 4c respectively protruding from the respective circular portions 3a, 4a at opposing areas of a diameter 3d, 4d of the same portions.

[0035] As visible in the figures and in particular in figures 8A and 8B, the outer outline of the head portions 3b, 3c, 4b, 4c is in its turn substantially circular, although of diameter larger than the diameter of the respective central portion 3a, 4a and although as far as to two diametrically opposing sectors for each rotor, as mentioned. The connecting portion 3f, 4f between the circular portion 3a, 4a and the head portions 3b, 3c, 4b, 4c is preferably beveled or blent, such that the head portions 3b, 3c, 4b, 4c take a crescent, or "labrys-like" outline.

[0036] In particular, the connecting portions 3f, 4f between the two head portions 3b, 3c; 4b, 4c of each rotor 3, 4 and the respective circular central portion 3a, 4a, are composed of surfaces concave towards the respective diameter 3d, 4d, so that between the two head portions 3b, 3c and 4b, 4c of each rotor 3, 4 two fillets 3e and 4e, also diametrically opposing, are substantially created and have, in plant view, a corrugated outline substantially of double-S shape, which is essentially recessed with respect to the respective head portions 3b, 3c; 4b, 4c.

[0037] The rotors 3, 4 are preferably different one from another.

[0038] Preferably, the connecting portions 3f, 4f, in particular, have thicknesses different one from another. The connecting portions 3f of the first rotor 3, that is of the rotor placed at the ignition means 5, have a thickness larger than the connecting portions 4f of the second rotor 4.

[0039] By thickness, the distance between opposed fillets 3e of the same connecting portion is meant.

[0040] Preferably, the connecting portions 3f of the first rotor 3 have a thickness about double with respect to the connecting portions 4f of the second rotor 4.

[0041] In other words, the central portion 3a of the first rotor can be preferably defined by arcs of a circle 30a having width α smaller than the width β of the corresponding arcs 40a of the central portion 4a of the second rotor 4. Preferably the width α is 1.5 times (150%) the width β.

[0042] This allows effectively sizing the chambers between the two rotors 3, 4 and the case 2, during the operation of the engine 1.

[0043] In addition, the head portions 4b and 4c of the second rotor 4 have depressions 4g concave towards the center of the second rotor 4 and adapted to reduce the pressure of the mixture 6, as it will be more evident in the following.

[0044] In the engine 1 the rotors 3, 4 are rotating in a mechanically synchronized way and preferably according to opposite rotation directions, inside the respective seats 2a, 2b of the case 2, around rotation pins 9. The seats 2a have an open circular outline and have a common area centrally to the case 2. In this area the two rotors 3, 4 can mutually intermesh and, in particular, the head portions 3b, 3c of the first rotor 3 can cooperate with the central portion 4a of the second rotor 4 and vice versa, so as to form movable chambers having variable size, defined by upper walls composed of surfaces of the case 2 of the engine and by side walls composed of surfaces of the rotors 3, 4 and/or of the case 2 itself, as better explained in the following during the description of the operation of the engine 1.

[0045] Note that the rotors 3 and 4 are shaped and arranged one with respect to another such that when the axes, or diameters, 3d, 4d, (see figures 8A and 8B) along which the respective head portions 3b, 3c and 4b, 4c of each rotor 3, 4 extend, are substantially orthogonal one to another, an engagement occurs between the respective circular central portions 3a or 4a of a rotor 3 or 4, which are in contact or in close proximity with the ends of the head portions 4b, 4c or 3b, 3c of the other rotor 4 or 3.

[0046] More in detail, as it will be seen in the following and as it can be seen in the herein attached drawings, during the synchronized rotation of the two rotors 3, 4, when the engine 1 is operating, the variable engagement of the head portions 4c, 4d of the second rotor 4 with the fillets 3e joining the head portions 3c, 3d of the first rotor 3, and the variable engagement of such fillets with the walls of the case 2, in addition to the engagement of the analogous fillets 4e of the second rotor with the same case 2, define with time (see for example figures 1 to 5) variable geometry (and thus variable volume) chambers for the fuel mixture and/or for its components, wherein the intake step/formation step of the mixture, the compression step, the expansion step of the same fuel mixture and the exhaust step of the combusted mixture (that is the respective exhaust gases) are carried out.

[0047] In the following, some of such chambers which take form during the rotation of the rotors 3 and 4 will be described, by referring to the step of the operating cycle of the engine they are associated with.

[0048] In particular, those chambers will be described as associated with the compression step, expansion step and intake step/formation step of the mixture 6 at the ignition of the mixture 6 itself.

[0049] As visible in figures and in particular in figure 3, the rotors 3, 4 have such a shape whereby they define, for a given time interval during their rotation, a first chamber 17 formed by side walls substantially exclusively belonging to the rotors 3, 4, which is associated to an operative step located between the ignition time of the mixture 6 and the expansion step of the mixture 6 itself, as it will be seen.

[0050] Referring also to figures 8A, 8B, in the herein illustrated embodiment the first chamber 17 is delimited more in detail by one of the central portions 3a of the first rotor 3, by one of the connecting portions 3f of the first rotor 3 and by the head portion 4b, with respective depression 4g, of the second rotor 4.

[0051] As previously mentioned, the upper and lower walls of the first chamber 17, not visible in the figures, typically belong to the case 2 of the engine 1.

[0052] Note in advance that the ignition of the mixture in the herein described engine 1 occurs during, or immediately before, the maximum compression of the fuel mixture 6 itself, in advance with respect to the time of maximum compression of the same mixture and, therefore, the aforesaid chamber 17, composed of side walls substantially exclusively belonging to the rotors 3, 4, can take form and preferably takes form during the compression step of the fuel mixture, and even more preferably immediately before the expansion step of the same burning mixture 6.

[0053] Furthermore, as better explained in the following, during the expansion step of the mixture 6 (that is of the respective combustion gases), a second chamber 18 takes form having side walls defined by the rotors 3, 4 and by the case 2, which has been supplied by the preceding chamber 17 at the end of the compression step, also thanks to the depressions 4g of the head portions 4c, 4d of the second rotor 4, as it will be evident by the observation of the herein attached figures. Such a chamber 18 is visible in figure 4 and is defined by a central portion 3a and by the respective connecting portions 3f of the first rotor 3, by a side wall 2a (seat of the first rotor 3) of the case 2 and by the head portion 4b of the second rotor 4.

[0054] As it can be noted in figure 4, on the first rotor 3 such a chamber 18 - thanks to the geometry of the two rotors 3, 4 - has a thrust shaped surface 16a, i.e. a wall developing along a substantially radial direction with respect to the rotor 3 which, during the expansion step of the mixture, is mainly responsible for the rotation of the first rotor 3, due to the action of the pressure of the mixture 6 expanding onto the same.

[0055] In particular, in the embodiment of the invention herein shown, the thrust shaped surface 16a is part of one of the connecting portions 3f. The other connecting portion 3f of the first rotor 3 is excluded from the chamber 18 as a result of the head portion 4b of the second rotor 4 intermeshing with the same connecting portion and, on the same, the action of the expanding mixture is extremely reduced (as it will be seen).

[0056] The pressure applied by the mixture 6 burning in the second chamber 18 on the central portion 3a of the rotor 3 is therefore almost completely balanced (that is it acts due to the circular outline of such a portion 3a essentially in a radial direction, without contributing to the rotation of the rotor 3), whereas the pressure applied by the mixture 6 burning (expansion) on the thrust shaped surface 16 of the rotor 3 is not balanced, therefore the rotor is rotated. In particular, the first rotor 3 is rotated clockwise in figure 4.

[0057] Analogously, while the synchronized rotation of the two rotors goes on, as visible in figure 5, in addition to the afore mentioned second chamber 18, which with the rotors' rotation changes in a chamber herein shown as 18.1 laterally defined only by the walls of the first rotor 3 and the case 2, a third chamber 19 takes form as arranged between the first rotor 3, the second rotor 4 and the case 2.

[0058] In particular, in the embodiment herein shown, such a third chamber is defined by a head portion 3c of the first rotor 3, by one of the central portions 4a, by a connecting portion 4f of the second rotor 4 and by the seat 2b of the case 2.

[0059] Referring to the above description, it is apparent how the expansion of the burning mixture 6 (combustion gas) present in the chamber 19, acts in unbalanced way on at least part of the aforesaid connecting portion 4f of the second rotor 4, which acts as thrust shaped surface 16b by providing a substantially radially-developed surface. Note that the thrust given by the expanding mixture (gas) after its ignition on the other walls of this third chamber 19 is substantially inconsequential on the rotation of the second rotor 4, since such walls extend essentially circularly, and thus the thrust of the expanding mixture on the chamber itself is substantially radial, thus not contributing to the rotation of such a rotor 4.

[0060] Between the first rotor 3 and the seat 2a of the case 2, as mentioned a chamber 18.1 is now present on which, due to the symmetry of the same, the forces applied by the mixture 6 have a resultant which generates a substantially null overall momentum. The ignition means 5 are of the type known in the art.

[0061] The ignition means 5 are arranged so as to ignite the mixture immediately before the formation, or during the formation, of the first chamber 17. In other words, the ignition means 5 are arranged so as to ignite the mixture before, or at worst at the condition of maximum compression of the mixture itself.

[0062] In the embodiment shown, the ignition means 5 are arranged in a fluidic communication with a fourth chamber 8 which is, as it will be seen, substantially associated with an intake step/formation step of the fuel mixture 6. The fourth chamber 8 takes form before the formation of the first chamber 17.

[0063] By the definition "before" it is intended previously during a cycle started by the intake step.

[0064] In the embodiment shown, the fourth chamber 8 takes form when the central portion 4a of the second rotor 4 is operatively coupled with a head portion 3b or 3c of the first rotor 3 and therefore one of the two fillets 3e of the first rotor 3 forms a chamber with the walls of the respective seat 2a of the case 2 (see for example figures 2 and 5). In other words, referring to the embodiment and to the arrangement of the rotors shown in figures, considering a straight line 11 connecting the rotation pins 9, the fourth chamber 8 takes form as long as the diameter 3d (fig. 6A) of the first rotor 3 forms a small angle with the straight line 11.

[0065] The fourth chamber 8, as visible for example in figure 2, has constant volume until the intermeshing of a head portion 4b, 4c of the second rotor 4 with a respective fillet 3e of the first rotor 3 starts, thus beginning the compression step of the mixture (figure 3). During a complete rotation of the first rotor 3, then the fourth chamber 8 takes form for two distinct periods. In the figures, the fourth chamber 8 is visible in figures 2 and 5.

[0066] The fourth chamber 8 is furthermore in fluidic communication also with first injection means 7a.

[0067] As for the ignition means 5, various typologies of first injection means 7a are known in the art and can be used with the present invention.

[0068] The ignition means 5 and the first injection means 7a thus are not shown in detail in the figures, but in figure 2 the positioning of the outlet of such means into the fourth chamber 8 is schematically reported.

[0069] Preferably, the engine 1 also has second injection means 7b. The second injection means 7b are in fluidic communication with a fifth chamber 10 (see in particular figure 2 or 7).

[0070] The fifth chamber 10 takes form between the first and the second rotors 3, 4, as long as a head portion 4b or 4c of the second rotor 4 is operatively coupled with the fillet 3a, 3e, and in particular with its circular central portion 3a, of the first rotor 3. Referring to the shown embodiment, the fifth chamber 10 takes form when the diameter 3d (fig. 6A) forms a substantially right angle with the straight line 11 (visible in figure 2). In the figures, the chamber 10 is visible in figure 3 and in the respective enlargement of figure 7.

[0071] Referring particularly to the afore mentioned figure 7, the chamber 10 is preferably divided in two sub - chambers 10a and 10b.

[0072] The sub - chambers 10a and 10b are in a limited fluidic communication, by means of a small section portion 10c.

[0073] As above mentioned, in this embodiment the sub - chamber 10a and the first chamber 17 coincide.

[0074] Like the first injection means 7a, the second injection means 7b can be of various typologies known in the art, and in figures 3 and 7 their outlet into the fifth chamber 10 is schematically shown.

[0075] In case of sub - chambers 10a and 10b, the second injection means 7b are fluidically connected to the second sub - chamber 10b.

[0076] By second sub - chamber 10b, the sub - chamber 10b farthest from the position of the fourth chamber 8 is meant.

[0077] Embodiments are however provided in which the second injection means 7b are not present.

[0078] The combination of first injection means (preferably acting before the mixture ignition) and second injection means (preferably acting after the mixture ignition step) is however preferable, since it has proven to provide higher power and better operating efficiency to the engine 1 according to the present invention.

[0079] The engine 1 is in addition provided with outflow means 12a, 12b for allowing exhausting the mixture 6 from the engine 1. In figure 5, in the sectional details, conduits 12a, 12b are visible which allow exhausting the mixture 6 by now combusted (combustion gases). Different typologies of outflow means known in the art can however be used in the present invention.

[0080] The outflow means 12a, 12b are typically obtained in the case 2 and preferably placed in a position substantially opposing to the position of the fourth chamber 8.

[0081] In figures 1 and 2 intake openings 13a, 13b are further visible in dotted line. The position of the opening 13a is schematized in figure 6. The position of the opening 13b, although not shown since not intersected by the plan of the shown section, is similar in its own seat 2b.

[0082] The intake openings 13a, 13b are fluidically connected to the seats 2a, 2b and allow the intake of air 14 to be mixed with the fuel 15 in order to form the mixture 6.

[0083] Different number, positioning and shape of the intake openings 13a, 13b can be used with the present invention. For example a larger number of openings or, at the worst, also only one opening at only one of the rotors 3, 4, typically the rotor 3 associated with the injection means 7a, could be provided.

[0084] Preferably, forced ventilation means, typically a compressor, are provided for forcing air into the openings 13a, 13b.

[0085] The depression, which actually takes form inside the engine 1 due to rotors' rotation, is lower than the depression which takes form in the conventional Otto-cycle engine as the piston is moved away from the top dead center, and could not be enough to draw an amount of air 14 optimal for the operation of the engine 1.

[0086] The forced ventilation means are able to apply a pressure on the air 14, until reaching a pressure preferably comprised between 1 and 1.5 bars.

[0087] The engine 1 is furthermore provided with synchronization means, which allow coordinating the relative rotation between the rotors 3, 4, in order to associate each position of the first rotor 3 with a specific position of the second rotor 4 and vice versa.

[0088] Such synchronization means are typically realized by means of proper gears 15. In the embodiment shown, the gears 15 are two intermeshing pinions, in order to synchronize the rotation of the two rotors 3 and 4 in opposite directions.

[0089] Referring to the figures the description of the operation of the engine 1 is now provided.

[0090] Note that, generally, such an operation provides the following steps of:

a) intake and/or formation of the fuel mixture, comprising a first step of feeding air into the case 2 through the aforesaid air inflow means 13a, 13b and a second step of feeding a fuel, for example gasoline, into the case 2 through the aforesaid fuel inflow means 7a so as to form, with the air, a fuel mixture 6 (see figures 1 and 2);

b) compression of the mixture 6, consisting in compressing such a mixture 6 between the two rotors 3, 4 (see figure 3);

c) ignition of the mixture 6 immediately before, or during, the formation of the first chamber 17, by means of the ignition means 5;

d) expansion, consisting in the expansion of the mixture 6, due to the respective burning, between the two rotors 3, 4 (see figure 4);

e) exhaust, consisting in discharging the now combusted mixture (and thus mainly composed of combustion gases), from the case 2 through the exhaust means 12a, 12b.

[0091] Therefore, during the initial intake step/formation step of the fuel mixture 6, the rotors 3, 4 are arranged as in figure 1 and the atmospheric air 14 is fed into the case 2 through the openings 13a, 13b. As mentioned, such an operation can be preferably aided by forced air means, typically a compressor.

[0092] Then, the rotors 3 and 4 during their own rotation are arranged as in figure 2. In this step, the injection of fuel 15 to form the mixture 6 occurs. In particular, the fuel 15 is introduced into the chamber 8 by the injection means 7a.

[0093] It has to be noted how the fourth chamber 8 is movable and has constant volume at least until the ignition of the mixture 6 whereby, also during the injection, the rotors 3, 4 are rotating. Referring to the embodiment of the figures, as described above, the first rotor 3 rotates clockwise, whereas the second rotor 4 rotates counter-clockwise. As afore mentioned, the ignition occurs before or during (and preferably before) the formation of the first chamber 17.

[0094] Preferably, the ignition occurs in advance with respect to the maximum compression comprised between 15° and 30°.

[0095] As it will be known to the person skilled in the art, such an angle refers to the rotation angle of the rotors 3, 4 whereby, after the spark provided for the ignition, the rotors 3, 4 travel an angular path of 15 - 30 degrees in order to reach the maximum compression point of the mixture 6.

[0096] In the embodiment shown, when the rotors 3, 4 have traveled such a path to be in a substantially intermediate position between the position of figure 2 and of figure 3, the ignition of the mixture 6 occurs by means of the ignition means 5. In particular, the ignition step preferably occurs after the injection step, but before at least the step of maximum compression of the mixture 6.

[0097] In figure 3 the compression step is shown, whereby the mixture 6 is constricted and thus compressed between the gap made between the two rotors 3 and 4, in the defined chamber 17 or 10a.

[0098] In this step, the fourth chamber 8 is not present any more, since the position of the fourth chamber 8 is taken by one of the head portions 3b, 3c of the first rotor 3.

[0099] In this step, as mentioned, the chamber 10 (or 17) has been created which, in the embodiment of the invention herein shown, is divided in the two sub - chambers 10a and 10b (figure 7).

[0100] More in detail, the first sub - chamber 10 acts, in this embodiment, as first chamber 17 laterally wholly defined by the rotors 3, 4, in which the compression step occurs in a controlled way.

[0101] As mentioned, advantageously such a chamber 17 (or 10a) has its own side walls defined substantially exclusively by walls of the aforesaid rotors 3, 4, and in particular by part of a head portion 4b or 4c of the second rotor 4 and by part of a fillet 3a, 3e of the first rotor 3, so as to make the compression step of the same mixture 6 more effective and adjustable (due to the selected geometry of such rotors).

[0102] In other words, when the rotors 3, 4 are arranged at 90 degrees one to another, between the two rotors 3, 4 two chambers take form, a first chamber 17 whose side walls are substantially formed by side walls belonging to the engines, and a second chamber 10b, preferably in a fluidic communication with a second injector 17b.

[0103] It has to be noted herein that the presence of the depression 4g on the respective head portion 4b or 4c of the second rotor 4, which contributes to define the side walls of such a chamber 17 as visible in figure 3, allows containing and thus adjusting the compression of the mixture 6 within limits defined during the design of the engine 1. Incidentally, as it will be seen in the following, such depressions 4g can serve as well to ease the leakage of the mixture 6 (or better of the respective combustion gases), during the expansion step of the mixture 6 from the afore said chamber 10a (or 17) to the chamber 10b, while the rotation of the two rotors 3, 4 goes on.

[0104] It is however possible that the small section 10c (figure 7) taking form between the part of a head portion 4b or 4c of the second rotor 4 and the part of a fillet 3a, 3e of the first rotor 3 which define the chamber 17 (or 10), allows a light leakage of the ignited mixture 6 from the fourth chamber 10 (or first chamber 17) towards the chamber 10b also in the arrangement taken by the rotors 3, 4 shown in figures 3 and 7.

[0105] In this step it is possible, if the second injection means 7b are present, introducing additional mixture 6 in the second sub - chamber 10b (or in general in the fifth chamber 10), in order to carry out a further fuel feeding into the engine 1.

[0106] Following this step, the expansion step of the burning mixture 6 (combustion gases) occurs, as visible in figure 4 and 5. As known, this is the "active" step of the engine cycle, since in this step the mixture 6 applied a force directed against the rotors 3 and 4, thereby causing their rotation.

[0107] It has to be noted in particular how such an "active" step contemporaneously affects the two rotors 3, 4, which are instantaneously always in angular positions differing one from another, such that during the expansion step the thrust on at least one of the rotors 3, 4 is always ensured.

[0108] More in detail, during the expansion step the aforesaid third chamber 18 (figure 4) takes form initially as derived by the aforementioned chamber 10b thanks to which, by means of the action of the mixture 6 burning on the thrust shaped surface 16a of the first rotor 3, the first rotor 3 is rotated.

[0109] In other words, initially the expanding mixture 6, which has now completely filled - also thanks to the respective depression 4g - the volume defined by a head portion 4b, 4c of the second rotor 4 and by one of the fillets 3a, 3e of the first rotor 3 (that is the chambers 10a, 10b that at this point became chamber 18 in figure 4), causes rotation (clockwise in figures) of the first rotor 3 due to its action on the aforesaid surface 16a which is part of one of the connecting portions 3f of the same rotor 3. When, upon the rotation of the rotor 3 as visible in figure 5, the chamber 18 disengages from the second rotor 4 and is therefore shown as chamber 18.1, the expansion action of the mixture 6 does not act any more thrusting the first rotor 3. For the mixture 6 retained inside the chamber 18.1, the position of figure 5 is therefore the exhaust step, that is to say the discharge step of the exhausted mixture 6, through the outflow means 12a.

[0110] Contemporaneously, a chamber 19 took form between the first rotor 3 and the second rotor 4 and has a thrust shaped surface 16b on the second rotor 4. Thanks to this, for the mixture 6 retained in the chamber 18, such a step is a prosecution of the expansion step and, in particular, a thrust step of the second rotor 4 made by the burning, and thus expanding, mixture 6.

[0111] Such a step ends by the exhaust step of the combusted mixture 6 from the chamber 19 towards the outflow means 12b, step not shown in the figures.

[0112] Therefore an engine cycle coincides with the rotation by 360 degrees of both the rotors 3, 4.

[0113] Note how the ignition of the mixture 6 before the formation of the first chamber 17 (or at the worst contemporaneously) allows the expanding mixture 6 to divide between the two seats 2a, 2b of the case 2, in order to thrust both the rotors 3, 4. Besides, the compression, ignition and expansion steps entirely occur inside the chambers taking form between the two rotors 3, 4, and between the rotors 3, 4 and the respective seats 2a, 2b.

[0114] Note that such a further thrusting activity of the mixture 6 expanding on the second rotor 4, due to that portion of mixture 6 contained in the chamber 19, although small, contributes making more efficient the exhaust step of the combusted mixture of the chamber 18 that is at the respective exhaust means 12a, just while the mixture 6 in the chamber 19 still actively thrusts the rotor 4 and, thus, the rotor 3, due to the respective reciprocal kinematic constraint obtained through gears.

[0115] It has to be noted how a complete rotation of the rotors 3, 4 is not needed in order to start a new operative cycle of the engine 1.

[0116] In fact, in the position of figure 4, in which the expansion of the shown mixture 6 occurs, the injection of additional mixture in the fourth chamber 8 can be carried on, in order to start a new operative cycle of the engine 1 every half - revolution (that is every rotation of 180° only) of the rotors 3, 4.

[0117] It has to be further noted how, in order to ensure a correct ratio between air 4 and fuel 17 also in the chamber 19, some air 14 has been previously fed into the seat 2b of the case 2 through the opening 13b, as shown in figure 1.

Claims

1. Internal combustion rotary engine (1), of the type supplied by a mixture (6) in order to carry out at least one intake step/formation step of a fuel mixture, a compression step, an expansion step following the ignition of the mixture and an exhaust step of the combustion mixture, comprising a case (2), a first rotor (3) and a second rotor (4), said first and second rotors being reciprocally counter - rotating and intermeshing in an operative condition, ignition means (5) for igniting said mixture (6), air inflow means (13a, 13b), fuel inflow means (7a, 7b) and outflow means (12a, 12b) for outflowing said mixture once combusted (6), said first and second rotors (3, 4) being shaped so as to define, at least between said mixture ignition step and said expansion step of the mixture, a first chamber (17) composed of side walls belonging substantially exclusively to said rotors, said ignition means being positioned so as to ignite said mixture before or during the taking form of said first chamber.

2. Rotary engine according to claim 1 having, during at least part of said expansion step, a second chamber (18) comprising thrust shaped surfaces (16a) on at least one rotor (3) to make rotate said at least one rotor (3).

3. Rotary engine according to claim 2 having, during at least part of said expansion step, a third chamber (19) comprising thrust shaped surfaces (16b) on at least one rotor (4) to cause a rotation of said rotor (4).

4. Rotary engine according to one of the preceding claims wherein said rotors have, in a section view, a central portion (3a, 4a) that is substantially circular, said circular central portion (3a, 4a) being provided with two head elements (3b, 3c, 4b, 4c) protruding from said circular central portion (3a, 4a) at opposing areas of a diameter (3d, 4d) of said circular portion (3a, 4a), said head portions (3b, 3c, 4b, 4c) having an outer outline at least partially circular, said circular central portion (3a, 4a) of said first rotor (3) and said head portions of said second rotor (4) defining, in an operative condition, chambers (8, 10, 17, 18, 19) having variable size depending on the relative rotation between said first rotor (3) and said second rotor (4), and vice versa.

5. Rotary engine according to claim 4, wherein said circular portions (3a, 4a) are connected to said circular portions by means of connecting portions (3f, 4f).

6. Rotary engine according to claim 5, wherein the connecting portions (3f) of said first rotor (3) have a thickness smaller than the connecting portions (4f) of said second rotor.

7. Rotary engine according to one of the preceding claims, wherein said ignition means (5) are in fluidic communication with a fourth chamber (8) arranged between the central portion (3a) of said first rotor (3) and said case (2), said fourth chamber (8) taking form when the central portion (4a) of said second rotor (4) is operatively coupled with a head portion (3b, 3c) of said first rotor (3).

8. Rotary engine according to one of the preceding claims, wherein said fuel inflow means (7a, 7b) comprise first injection means (7a) placed in a fluidic communication with said fourth chamber (8).

9. Rotary engine according to claim 6, wherein a fifth chamber (10) takes form between said first and second rotors (3, 4), when a head portion (4b, 4c) of said second rotor (4) is operatively coupled with said central portion (3a) of said first rotor.

10. Rotary engine according to claim 9, wherein said fifth chamber (10) is divided in at least one first (10a) and one second (10b) sub - chamber, said first and second sub - chambers (10a, 10b) being fluidically communicating one to another by means of a small section (10c).

11. Rotary engine according to claim 9 or 10, wherein said fuel inflow means (7a, 7b) comprise second injection means (7b) placed in a fluidic communication with said fifth chamber (10).

12. Rotary engine according to claims 10 and 11, wherein said second injection means (7b) are fluidically connected with said second sub - chamber (10b) of said fifth chamber (10).

13. Rotary engine according to one of the preceding claims, comprising forced ventilation means for inflowing air into said case.

14. Method for producing kinetic energy by means of a rotary engine according to one of claims 1 to 13, comprising in sequence the steps of:

a) intake and/or formation of the fuel mixture, comprising a first step of feeding air into said case through said air inflow means and a second step of feeding said fuel into said case through said fuel inflow means, so that to form, with the air, a fuel mixture;
b) ignition of said mixture by means of said ignition means;
c) compression, consisting in compressing said mixture between said two rotors;
d) expansion, consisting in expanding said mixture between said two rotors;
e) exhaust, consisting in discharging said mixture, being now a combusted mixture, from said case through said exhaust means;
characterized in that between said step b) of ignition of the mixture and said step e) of expansion of the mixture, between said two rotors (3, 4) at least one chamber having side walls defined substantially exclusively by said rotors, takes form, and **in that**, in said step b, the mixture is ignited immediately before or during the taking form of said chamber.

15. Method according to claim 14, wherein during said step e) of expansion of the mixture, at least one chamber having at least one thrust shaped surface on at least one of said rotors, takes form between said two rotors in order to force the rotation of said at least one rotor.

16. Method according to claim 15, wherein during said step e) of expansion of the mixture, at least one first chamber and one second chamber take form contemporaneously and/or in succession between said two rotors, said at least one first chamber having a thrust shaped surface on said first rotor in order to force the rotation of said first rotor, and said second chamber having a thrust shaped surface on said second rotor in order to force the rotation of said second rotor.

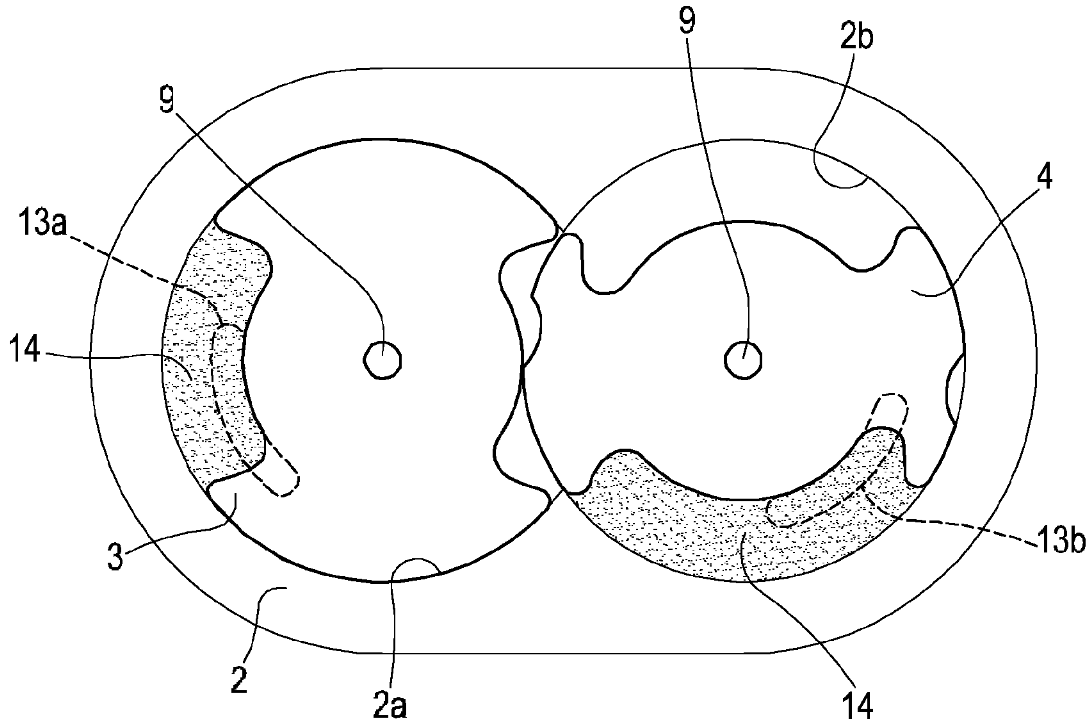

Fig. 1

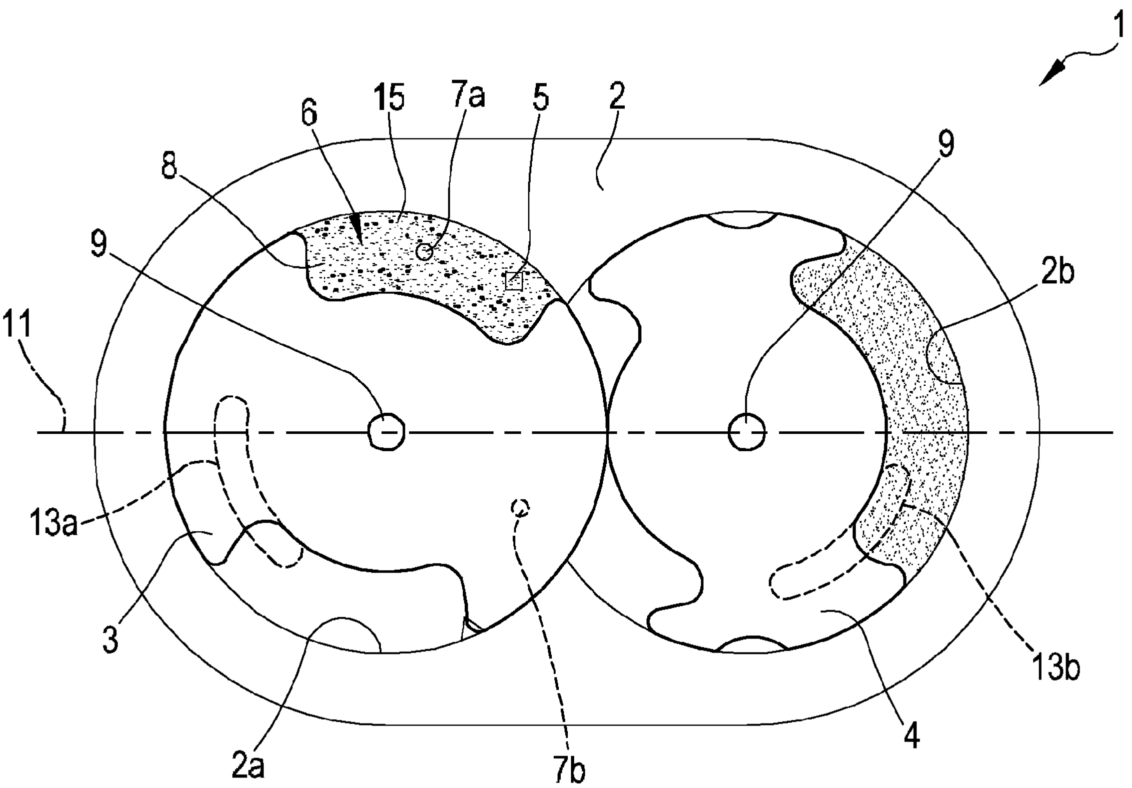

Fig. 2

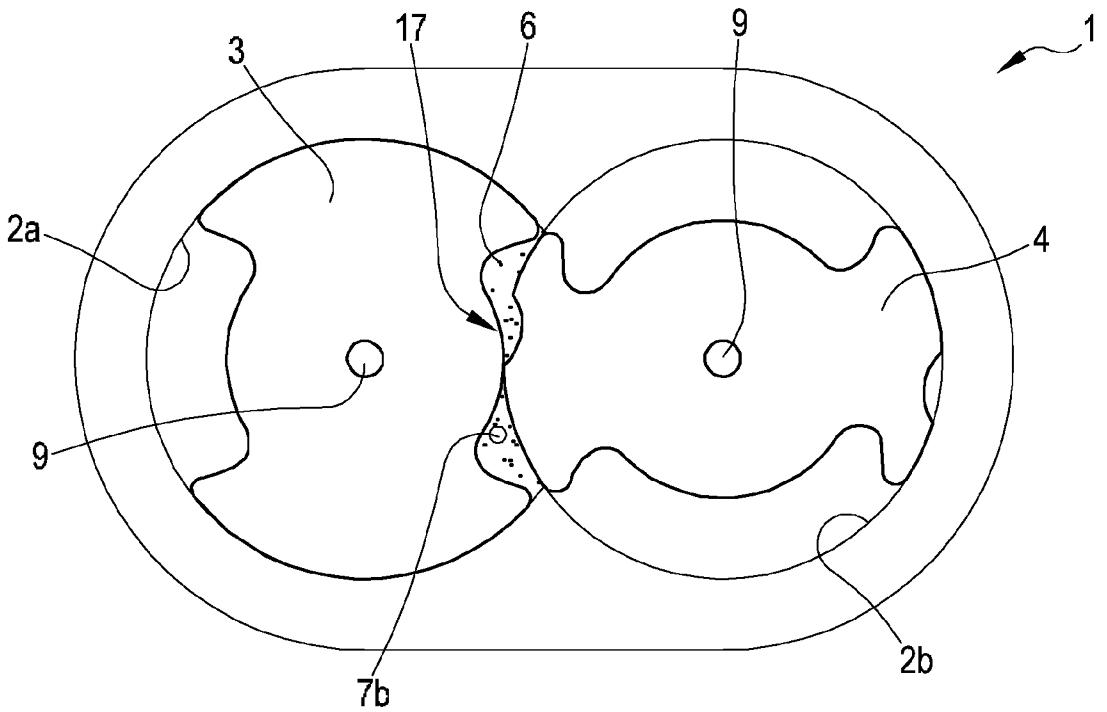

Fig. 3

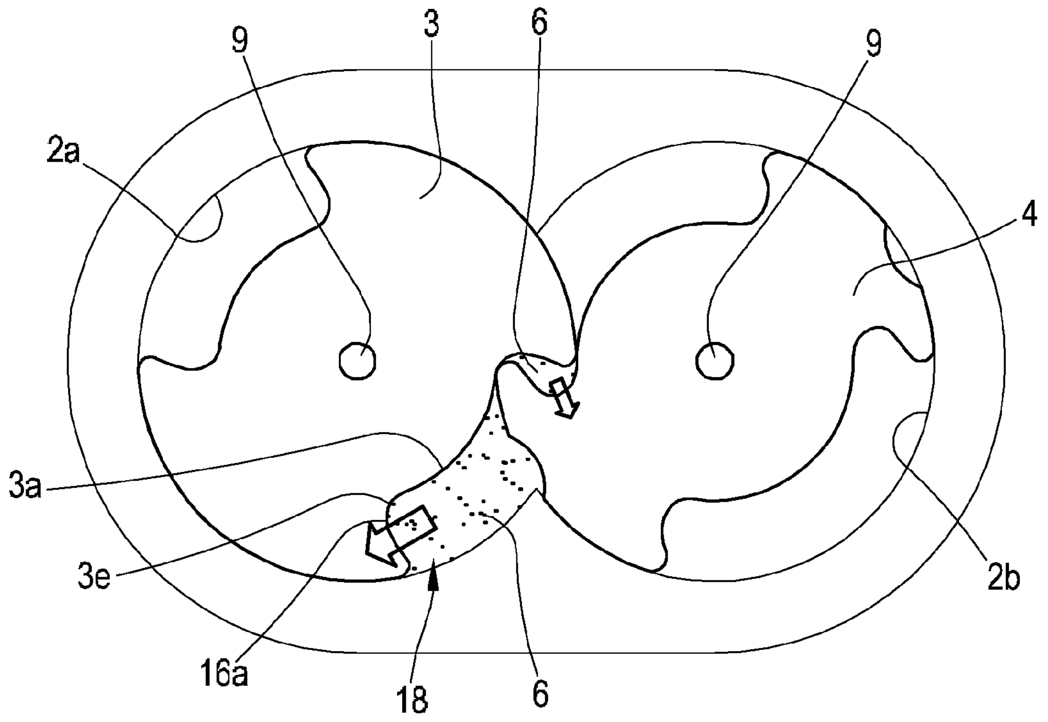

Fig. 4

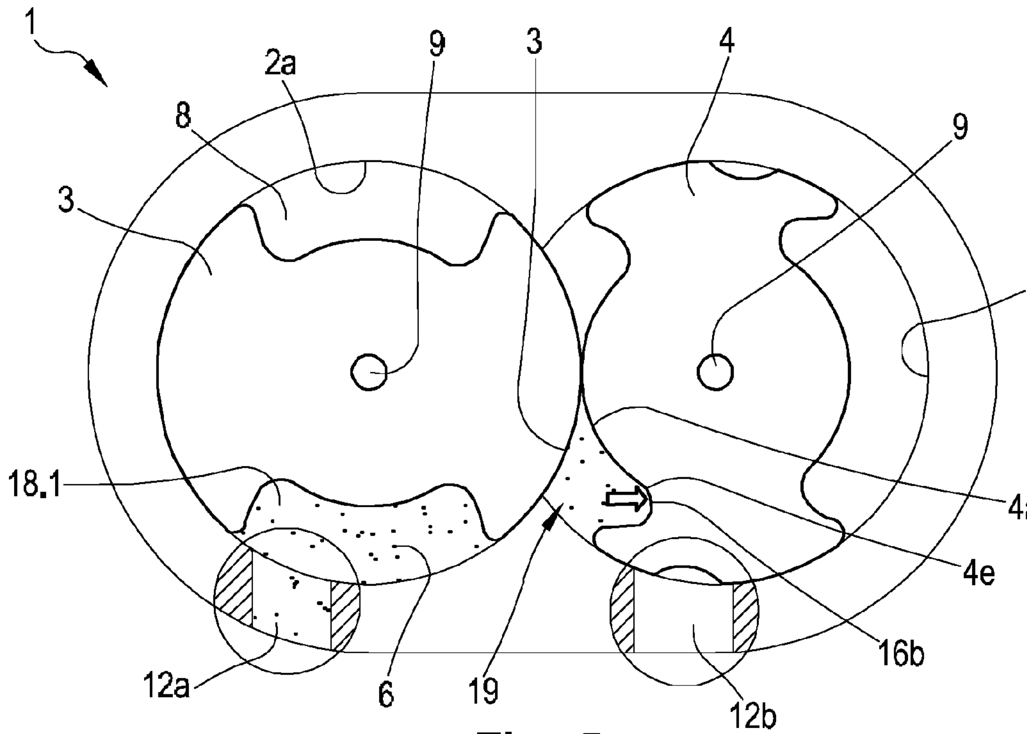

Fig. 5

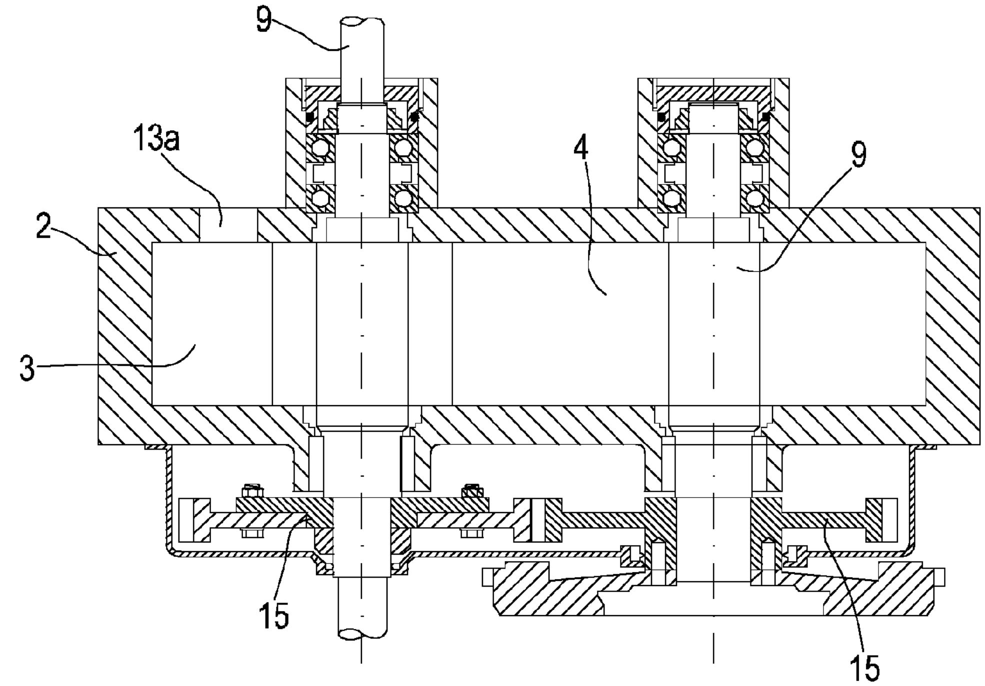

Fig. 6

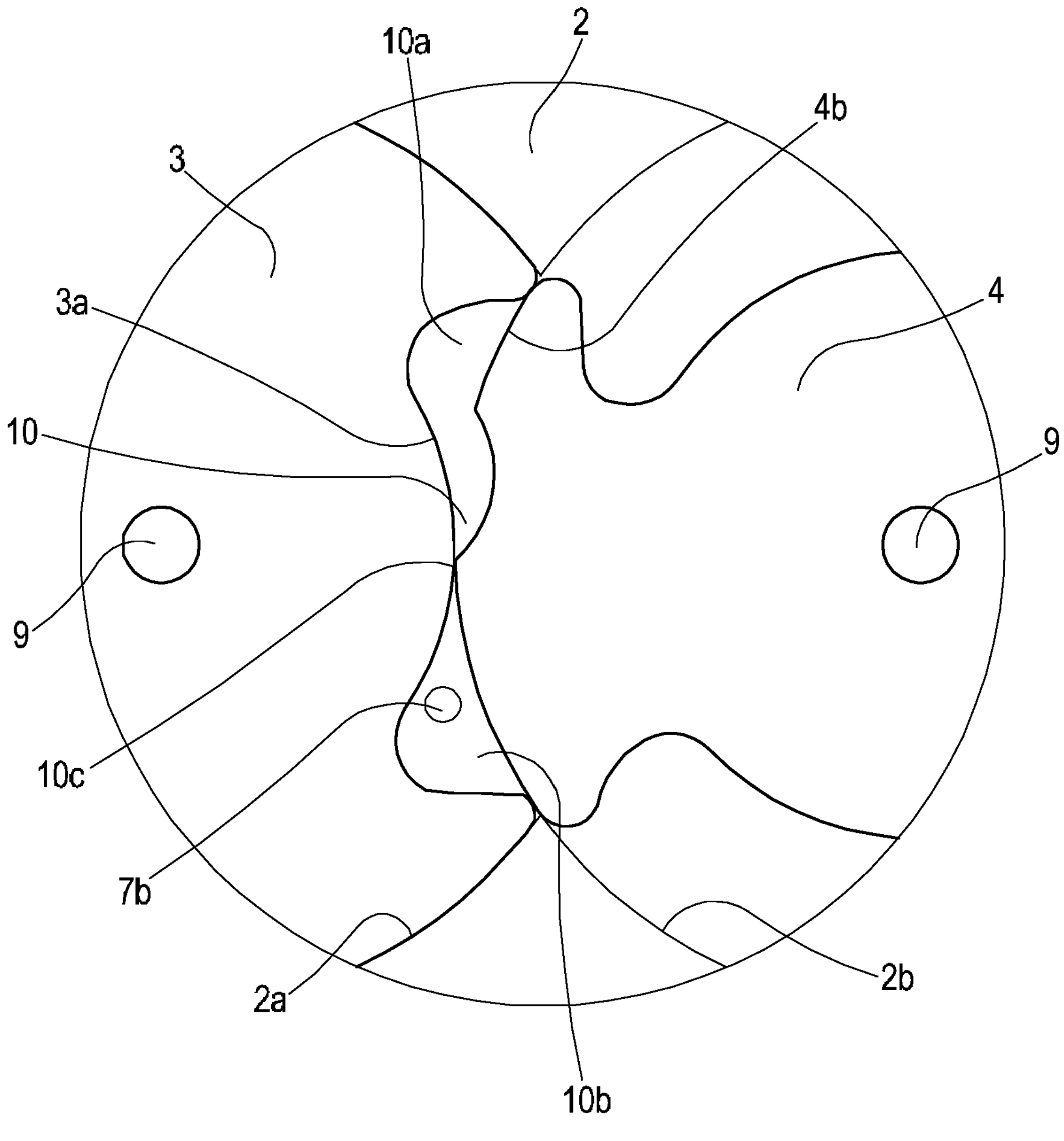

Fig. 7

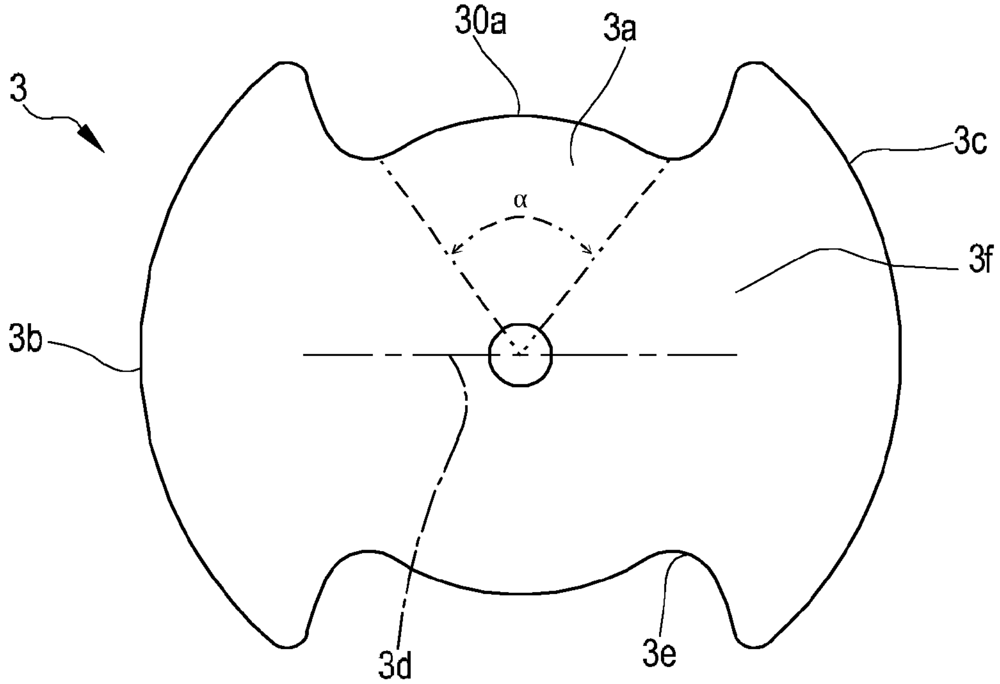

Fig. 8A

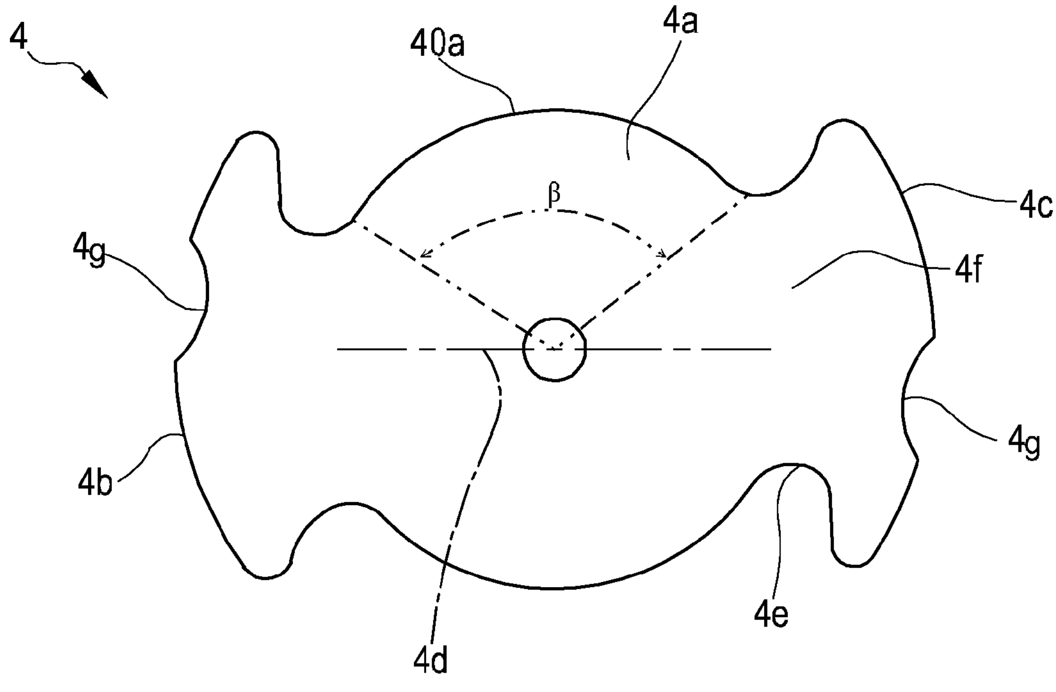

Fig. 8B

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EUROPEAN SEARCH REPORT

Application Number
EP 15 16 0404

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	25 August 2015	Alquezar Getan, M

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