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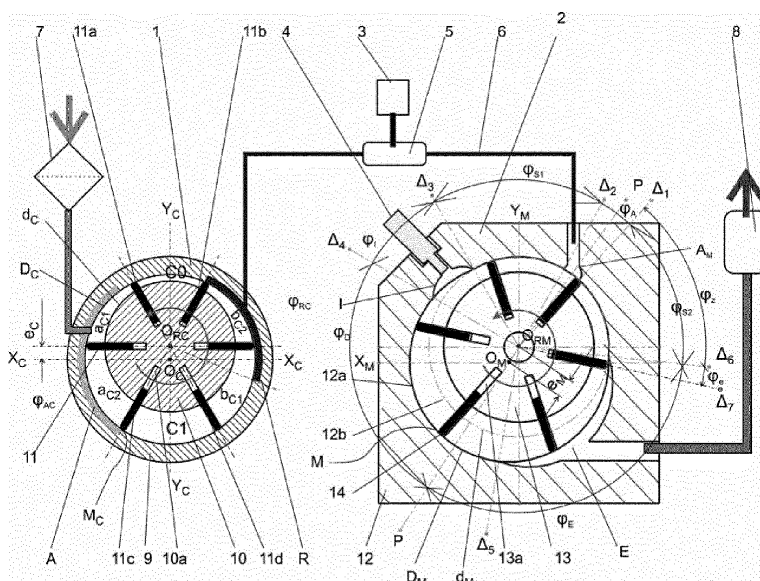
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(54) **Internal combustion rotary engine**

(57) The invention describes an internal combustion rotary engine designed for the operation of vehicles or certain tools, machinery, and equipment.

Internal combustion rotary engine comprising of a volumetric blade rotary compressor (1), a volumetric blade rotary engine (2) consisting of a housing (12), which holds rotor (13), which is equipped with some slots (13a), on which blades (14) are mounted. Housing (12) is built

inside with a complex bore consists of two cylindrical bore (12a), (12b), concentric with rotor (13). The compressed air or mixed fuel is taken in by the constant volume chambers (a_0) and (b_0) through the engine supply channel (AM) located in the secondary bore (12b) area. The constant volume chambers (a_0) and (b_0) go to the ignition channel (I), the ignited gas acting upon the blades and thus produces useful work.



Description

[0001] The invention describes an internal combustion rotary engine designed for the operation of vehicles or certain tools, machinery, and equipment.

[0002] There exist many technical solutions to internal combustion engines with pistons already.

[0003] The disadvantages of piston engines consist of low efficiency, reduced power/weight ratio and a complex distribution system, which requires dynamic modifications depending on the operating mode.

[0004] The Wankel engine [US3359954; US2988065; US4490101; EP0337950] is among the best known rotary engines which obtain their rotational movement using a triangular rotor that spins in an oval housing. The blades that pass through the corners of the triangular rotor divide the space between the rotor and the oval housing into 3 chambers which change their volumes according to the position of the rotor. During one complete revolution every chamber attached to a side of the rotor changes its volume from the minimum to the maximum value and back again, marking specific phases for the four-stroke engines: intake, compression, ignition and exhaust.

[0005] The main disadvantage of the Wankel engine is that it is less efficient than piston engines, which results in higher fuel consumption for the same supplied power. The difficulty of achieving proper sealing between the rotor and the stator is a major disadvantage of this engine since it contributes to increased emissions of pollutants and the need for complex depollution installations. Another disadvantage of Wankel engines is that their rotor performs a planetary motion which is a source of vibration that limits engine speed and affects performance.

[0006] U.S. Patent 7556015 "Rotary device for use in the engine" describes a solution comprising of a concentric stator and a rotor arrangement. The cross section of the stator is cylindrical and the rotor has a polygonal cross section (with curved sides and filleted corners). The sealing is accomplished by means of blades mounted on the stator. The blades have a radial motion given by some actuators.

[0007] The disadvantage of this engine is the impossibility of efficient energy conversion, as the gas chamber volume variation from the minimum to the maximum value and back again corresponds to a small angle of rotation of the rotor (about 60° for an engine with 6 blades). Another disadvantage is the complexity of the motor drive blade system, especially in the version where the blades are mounted on the stator.

[0008] The generally known disadvantages of internal combustion engines derive from the mechanism for obtaining the rotational movement. Thus, the main disadvantages of piston engines result from reciprocating motion and the existence of dead points.

[0009] A part of Wankel engine disadvantages result from the planetary motion of the rotor and from the transmission of the rotor to the motor shaft with multiplier ratio that reduce the torque of the engine shaft. Another disadvantage is the difficulty to achieve a reliable sealing, due the lack of compensation.

[0010] The present invention solves the technical problems by developing a simple and efficient internal combustion rotary engine, with low vibration levels, that can operate efficiently at speeds over 10,000 rpm, providing a power-to-weight ratio higher than that of all known engines and that can be designed and manufactured for a wide range of power and applications.

[0011] Another purpose of the invention is to achieve an internal combustion rotary engine that offers a constant torque relative to the angle of rotation of the motor shaft, without requiring a flywheel.

[0012] At the same time, the invention aims at achieving an internal combustion engine that has a dynamic behaviour with very low response times and is able to accelerate quickly from minimum speed to maximum speed.

[0013] According to this invention, the rotary combustion engine comprises a rotary volumetric blade compressor, which compresses the air and sends it through a gallery, where fuel is introduced, to a rotary volumetric blade engine, composed of a housing with a complex bore obtained by combining the two cylindrical bores. The bores have parallel axes, with one having a larger diameter than the other.

[0014] The rotor with blades is concentric with the smaller diameter bore. The rotor has some radial slots on which the blades slide. The space between two blades, the housing complex bore, the side covers and the rotor forms chambers. When the blades slide on a large diameter bore, the chambers' volume changes continuously. When the blades slide on small diameter bore, the volume remains constant.

[0015] The fuel mixture is introduced between the blades through a feeder placed on the smaller bore, which is concentric with the rotor shaft. Here, due to the concentric arrangement of the shaft and bore, the volume of the chamber between the two blades remains constant. From here on, the intake phase is complete, and because of the movement of the rotor, the chambers pass successively through the stages of ignition and exhaust.

[0016] The propagation of the ignition (continuous combustion).

[0017] When the engine starts, the ignition system produces a series of sparks in the ignition channel.

[0018] After the engine starts and warms up, igniting the fuel in each chamber is no longer necessary, due to the fact that ignition is propagated.

[0019] The ignition is propagated continuously from the chamber that is already burning to the next chamber, due to the fact that they communicate through the ignition channel.

[0020] This rotary internal combustion engine can run on any liquid or gaseous fuel. The fuel can be introduced in a mixture chamber or directly into the ignition channel, by injection.

[0021] Fuel injection can be anywhere between the engine intake channel and the ignition channel.

[0022] Building a rotary internal combustion engine according to the model described by this invention brings the following advantages:

- small and compact engines which generate high power
- high efficiency
- very low levels of vibration and noise
- simplicity of construction by eliminating valves and using a continuous burning.

Brief description of the drawings

[0023] These and other characteristics of the invention will be clear from the following description, given as a non-restrictive example, with reference to the attached drawings, wherein:

- figure 1 is a schematic diagram of the rotary internal combustion engine
- figure 2 shows a cross section through the internal combustion rotary engine, where the rotary engine represents the version with a mixture chamber
- figure 3 shows a cross section through the internal combustion rotary engine, where the rotary engine represents the version with fuel injection in the ignition channel
- figure 4 shows the cross section through the compressor
- figure 5 shows the beginning of the intake stroke and the end of the exhaust stroke
- figure 6 shows the beginning of the ignition stroke
- figure 7 shows the propagation of ignition
- figure 8 shows the exhaust stroke
- figure 9 shows the profile of the complex bore of the rotary engine housing
- figure 10 is a longitudinal section of the internal combustion rotary engine, where the rotary engine represents the version in which the engine and the compressor are coaxially mounted
- figure 11 is a front view of a parallel mounting version of the rotary engine and compressor
- figure 12 shows the specially-shaped blades for improved seal in a cross section
- figure 13 shows the specially-shaped blades for improved seal and wear compensation in a longitudinal section.

[0024] According to this invention, the internal combustion rotary engine consists of a volumetric blade rotary compressor 1, which compresses the air and sends it to a volumetric blade rotary engine 2, equipped with a fuel supply system 3 and an ignition system 4.

[0025] The fuel supply system 3 can be placed in a mixture chamber 5 on gallery 6 which fuels engine 2, or it can be placed directly inside engine 2 (fig. 3). The fuel system 3 may be of the carburettor type or of the injector type. If it is of the carburettor type, it should be placed on gallery 6. If it is of fuel injection type, it should be mounted in the ignition channel I.

[0026] Compressor 1 takes in air from the atmosphere through filter 7 and sends it, at pressure p_c , to rotary engine 2. The fuel combustion occurs in rotary engine 2. The burning gas expands inside rotary engine 2 and produces mechanical energy, a part of this being used to drive compressor 1. After the expansion of the gas inside rotary engine 2, the burnt gas is discharged into the atmosphere through exhaust system 8.

[0027] Depending on the value of the pressure of the intake gas of engine 2, the air supply pressure of rotary engine 2 may be obtained by using a volumetric blades compressor 1, or a cascade system consisting of either a turbocharger

and a volumetric compressor, or only of a turbocharger. Choosing a compressor or cascade system depends on factors such as the type of fuel used, the compression ratio, or others.

[0028] The internal combustion rotary engine can operate with any liquid or gaseous fuel.

[0029] Volumetric blade compressor 1 is designed as a blade pump, already known in itself. Compressor 1 is composed of a housing 9, having a cylindrical bore D_C , a rotor 10 with some slots 10a, on which some blades 11 are mounted. Rotor 17 has its center of rotation in point O_{RC} , moved in relation to the center bore O_C of housing 9 with the eccentricity e_C .

[0030] During the movement of the rotor 10, in the arrow direction, the volume of the chamber between two blades and the side covers is constantly changed. The change of the chambers' volume occurs due to the variation of the R_{MC} radius. R_{MC} stands for the distance from the center of rotation O_{RC} to a point M_C on blade 11. Point M_C is placed on the sealing line of blade 11.

[0031] The minimum volume of the chamber is achieved when two successive blades are placed symmetrically to the axis Y_C-Y_C , in the place nearest to housing 9 (fig. 2, top), while the maximum volume is reached when the two blades move to the opposite position. The change of the chamber volume occurs by the surface variation between two successive blades 11a, 11b, inner diameter D_C of housing 9 and the outer diameter d_c of rotor 10.

[0032] In operation, the blades 11a and 11b pass successively from the position "C0", of minimum section, to the position "C1", of maximum section. Thus, the chambers a_{c1} , respectively a_{c2} , continuously increase their volume, performing intake, from channel A.

[0033] From the maximum-section position "C1", blades **11c** and **11d** return to the minimum-section position "C0". Thus, chambers b_{c1} , respectively b_{c2} , constantly decrease their volume, and discharge the air out into the discharge channel R.

[0034] From the discharge channel R, the compressed air reaches, through gallery 6, mixing chamber 5, where the fuel is introduced, by means of system 3. The fuel supply system 3 can be designed based on the principle of carburetors or injectors.

[0035] The ignition system 4 is designed to initiate the fuel combustion, meant as a continuous combustion. In case of accidental interruption of combustion during engine operation, a sensor controls the re-ignition of the fuel mixture.

[0036] The ignition system 4 can be set to provide a continuous spark of a certain frequency.

[0037] The engine 2 consists of a housing 12, comprising rotor 13, which is equipped with some slots 13a, on which some blades 14 are mounted. Housing 12 is designed inside with a complex bore consisting of two cylindrical bores, a main bore 12a and secondary bore 12b. The axis of the main bore 12a, of diameter D_M , passes through the O_M point, while the axis of the secondary bore 12b, of diameter d_M , passes through the O_{RM} point.

[0038] The rotation axis of the rotor 13 is collinear to the axis of the secondary bore 12b and it is moved to the axis of the main bore 12a with eccentricity e_M . Rotor 13 is concentric to the secondary bore 12b.

[0039] The space between two successive blades (e.g. 14a, 14b), the inner bore 12a, the outer diameter of the rotor 13 and the lateral side covers forms a sealed chamber. Thus, in a six-blade rotary engine, six sealed chambers are formed. They are labelled (figure 2) with a_0 , a_1 , a_2 , b_0 , b_1 , b_2 .

[0040] During the movement of the rotor 13 in the arrow direction, when at least one of the two successive blades leaves the secondary bore 12b, the chamber volume changes continuously. The chamber volume change occurs due to the blade radius R_M variation, from the rotation center O_{RM} to the blade point M, along with the movement of the rotor 13. Point M is placed on the sealing line on blade 14.

[0041] The plane P which passes through the axis of bores 12a and 12b divides the complex bore of the housing into two symmetrical sides.

[0042] As long as the center of mass of the camera section is located on the left of the plane P and at least one blade of this chamber is in contact to main bore 12a, the chamber section is growing (chambers a_1 , a_2).

[0043] When the center of mass of the chamber section passes to the right side of plane P, the chamber section is decreasing, (chambers b_1 , b_2) until both blades which form the chambers pass from the main bore 12a to secondary bore 12b.

[0044] When two successive blades, which form a chamber (e.g. a_0) are on the secondary bore 12b, the chamber volume remains unchanged, as this is the minimum volume.

[0045] The maximum volume of the chamber is reached when the two successive blades on the main bore are in a symmetrical position to plane P, in contact to main bore 12a.

[0046] Engine 2 is charged with the mixed fuel produced in chamber 5, pressure p_c , through charging channel A_M .

[0047] Based on a comparison with the operation of four-stroke engines, the operating cycle of the rotary engine is completed in five strokes. Two strokes take place in compressor 1 (intake and compression), while three of them occur in engine 2 (transfer, ignition and power, and exhaust).

Stroke 1: Intake

[0048] This stroke takes place in compressor 1. For the chamber formed of the blades 11a, 11b, the intake begins

when point M_C of the blade 11a crosses line Δ_{C1} and ends when point M_C of the next blade 11b crosses line Δ_{C2} .

[0049] During this stroke, the atmospheric air fills the a_{C1} , a_{C2} compressor chambers. Intake is due to the increase in the chamber volumes formed in between two successive blades, because of the travel of the blades in the slots of rotor 10 and the subsequent increase of the R_{MC} radius.

Stroke 2: Compression

[0050] The air compression takes place in compressor 1 as well. For the chamber formed of the blades 11c, 11d, the compression begins when the point M_C of the blade 11c crosses line Δ_{C3} and ends when the point M_C of the next blade 11d crosses line Δ_{C5} .

[0051] During this stroke, the air is sent through compression channel R and gallery 6 to engine 2. The air pressure in compression channel R is p_c .

[0052] Compression is due to the volume decrease of the chambers formed between two successive blades, by the entrance of the rotor 10 blades and the decrease of the R_M radius.

Stroke 3: Transfer and Engine Intake

[0053] Engine Intake is the first stroke of the engine itself. For the engine chamber formed of the blades 14a, 14b, the engine intake begins when the point M of blade 14a crosses line Δ_1 and ends when the point M of the next blade 14b crosses line Δ_2 .

[0054] During this stroke, the air compressed at pressure p_c is taken in by the blade engine 2, through the engine supply channel A_M , and transferred to the ignition channel I. Channel A_M is located in the secondary bore 12b area, and the compressed air or mixed fuel charge is achieved in the constant volume chambers a_0 and b_0 .

[0055] The fuel can be introduced into a mixing chamber 5, or directly into rotary engine 2, in the ignition chamber (formed by ignition channel I).

Stroke 4: Ignition and Power

[0056] The ignition and power takes place in engine 2 as well. For the engine chamber formed by the blades 14a, 14b, this stroke begins when point M of the blade 14a crosses line Δ_3 and ends when the center of mass of the chamber section passes to the right side of plane P.

[0057] The continuous movement of rotor 13 determines chamber a_0 , with mixed fuel at pressure p_c , to reach the ignition channel I area.

[0058] A spark produced by the ignition system determines fuel ignition. The fuel ignition triggers an increase in pressure and gas temperature. The ignition gas acts with different forces upon the blades due to the latter's different surface. Thus, the engine produces useful work.

[0059] After the engine start and warm-up, the fuel ignition for each chamber is no longer necessary, due to the fact that ignition is transmitted. The ignition is transmitted from one chamber to the next one due to their communication through ignition channel I.

Stroke 5: Exhaust

[0060] For the engine chamber formed by the blades 14a, 14b, this stroke begins when point M of the blade 14a crosses line Δ_5 and ends when point M of the next blade 14b crosses line Δ_6 .

[0061] During this stroke, the exhaust of ignited gas takes place. The chambers which exceed middle plane P and decrease their volume are connected to the exhaust channel. The gas passes from the exhaust system into the atmosphere.

[0062] The operating cycle of volumetric blade rotary compressor 1 is presented on basis of figure 4.

[0063] In figure 4, the following symbols have been used:

- Δ_{C1} -the line which limits the beginning of the intake channel A
- Δ_{C2} - the line which limits the end of the intake channel A
- Δ_{C3} - the line which limits the beginning of the discharge channel R
- Δ_{C4} - a line positioned at angle φ_{ZC} from Δ_{C3}
- Δ_{C5} - the line which limits the end of the discharge channel R
- Δ_{C6} - a line positioned at angle φ_{ZC} from Δ_{C5} .

[0064] The lines Δ_{C1} - Δ_{C6} define the following functional angles:

- φ_{AC} - the angle covered by the intake channel I (Δ_{C1} - Δ_{C2})
- φ_{RC1} , the angle of the beginning of the discharge delay (Δ_{C3} - Δ_{C4})
- φ_{RC} , the angle covered by the discharge channel (Δ_{C4} - Δ_{C5})
- φ_{AC1} - the angle of the beginning of the intake delay (Δ_{C6} - Δ_{C1})
- $\varphi_{SC1} \geq \varphi_{ZC} = 2\pi/z$, the angle of separation between the intake channel A and the discharge channel R (Δ_{C1} - Δ_{C4}); where φ_{ZC} is the angle between two successive blades, and z_c is the number of blades
- $\varphi_{SC2} = \varphi_{ZC} - \varphi_{RC1}$, the angle of separation between intake channel A and discharge channel R (Δ_{C2} - Δ_{C4})

[0065] For a proper operation of compressor 1, the angles that cover the intake and discharge channels need to comply with the next equations:

$$\varphi_{AC} \leq \pi - \varphi_{ZC} ; \quad \varphi_{RC} \leq \pi - \varphi_{ZC} , \quad (1)$$

[0066] The value of the angle of the beginning of the intake delay φ_{AC1} is determined from the condition of near pressures between the chamber that is just coming into contact with the intake channel and the intake channel A itself.

[0067] This condition is fulfilled when point M_C of blade 11a crosses the line Δ_{C1} and the chamber between blades 11a and 11b increases its volume so much that the pressure in that chamber nears the pressure from the intake channel.

[0068] The value of the angle of the beginning of the discharge delay φ_{RC1} is determined from the condition of near pressures between the chamber that is just coming into contact with the exhaust channel and the discharge channel itself.

[0069] This condition is fulfilled when point M_C of blade 11d crosses the line Δ_{C4} and the chamber between blades 11d and 11c decreases its volume so much that the pressure in that chamber nears the pressure from the discharge channel.

[0070] In figures 5-8, the following symbols have been used:

- Δ_1 -the line which limits the beginning of the intake channel
- Δ_2 - the line which limits the end of the intake channel
- Δ_3 - the line which limits the beginning of the ignition channel
- Δ_4 - the line which limits the end of the ignition channel
- Δ_5 - the line which limits the beginning of the exhaust channel
- Δ_6 - the line which limits the end of the exhaust channel
- Δ_7 -the line which limits the beginning of the exhaust and intake phases overlap

[0071] Lines Δ_1 - Δ_7 define the following functional angles:

- φ_A - the angle of the intake channel (Δ_1 - Δ_2)
- φ_D - the angle of the power stroke (Δ_3 - Δ_5)
- φ_E - the angle of exhaust (Δ_5 - Δ_6)
- φ_I - the angle that covers the ignition channel (Δ_3 - Δ_4)
- φ_e - the angle of exhaust delay (Δ_6 - Δ_7)
- $\varphi_{S1} \geq \varphi_Z = 2\pi/z$, the angle of separation between the intake channel A_M and the ignition channel I (Δ_2 - Δ_3); where φ_Z is the angle between two successive blades (Δ_6 - Δ_7) and z is the number of blades
- $\varphi_{S2} = \varphi_Z - \varphi_e$ the angle of separation between the intake channel A_M and exhaust channel E (Δ_6 - Δ_2).

[0072] Figure 5 corresponds to the phase of intake beginning and exhaust end for chamber b_0 . The charging phase for these chambers begins when a blade 14b crosses the line Δ_1 , and ends when the next blade 14c crosses the line Δ_2 .

[0073] As soon as the axis of blade 14b crosses the line Δ_1 , chamber b_0 is connected to intake channel A_M . The compressed air, or the fuel mixture, enters and goes from the charging channel A_M into chamber b_0 , forcing the exhaust of the rest of the ignited gas in the chamber. The overlap of the exhaust and charging stages lasts until blade 14c crosses line Δ_7 .

[0074] Figure 6 corresponds to the beginning stage of the ignition for chamber a_0 , when blade 14a crosses line Δ_3 .

[0075] At this point, chamber a_0 is isolated from the neighbouring chambers a_1 and b_0 .

[0076] When blade 14b crosses line Δ_2 , the compressed air transfer from compressor 1 to engine 2 is completed. Neglecting the leakage due to the flow of the fluid, the transfer can be considered to take place at constant pressure, namely pressure p_c ensured by the compressor.

[0077] Figure 7 corresponds to the phase of transmission of the ignition from chamber a_1 to chamber a_0 , when blade 14a crosses line Δ_3 . At this point, chambers a_1 and a_0 communicate with each other through ignition channel I.

[0078] Thus, the ignition initiated by the ignition system 4 in channel I and in the previous chamber is constantly being transmitted to the next chamber due to the communication of the chambers which are separated by the blade that goes through channel I.

[0079] Figure 8 represents the completion of the exhaust phase. After blade 14a crosses line Δ_5 , chamber b_2 between the blades 14a and 14b reduces its volume, and gas is directed into the exhaust channel. The exhaust of the chamber continues until the next blade, 14b, crosses the line Δ_6 .

[0080] As long as any blade 14 crosses the area between lines Δ_7 and Δ_6 , the chamber located in front of that blade, is linked simultaneously to the exhaust and intake channels. The overlap of the exhaust and engine intake stroke lasts until the blade crosses the space between lines Δ_7 and Δ_6 .

[0081] Figure 9 represents the profile of the complex bore of the rotary engine housing 12.

[0082] Housing 12 is constructed inside with a complex bore composed of two cylindrical bores, main bore 12a and secondary bore 12b. The axis of main bore 12a, of diameter D_M , passes through point O_M , while the axis of secondary bore 12b, of diameter d_M , passes through point O_{RM} . The axis of secondary bore 12b is moved to the axis of main bore 12a with eccentricity e_M .

[0083] The rotor 13 is collinear to the axis of the secondary bore 12b.

[0084] The intake channel is placed in the secondary bore 12b area, because in this area the chamber's volume remains constant.

[0085] In order to avoid the shocks, main bore 12a and the secondary bore 12 b must be connected with tangent lines or other curves such as fillets.

[0086] In order to obtain different ratios between the minimum and maximum volume of the chambers, the main bore may have a complex shape 12c. In this case, the main bore doesn't need to be symmetrical with plane P. Using a complex shape 12c for the main bore offers advantages for achieving desired values for angles of power and exhaust.

[0087] Compressor 1 is driven by engine 2 and it can be mounted coaxially to rotary engine 2 (fig. 10), or parallel to it (fig. 11).

[0088] In case it is mounted coaxially, shaft 15 supports both rotor 10 of compressor 1 and rotor 13 of engine 2. Shaft 15 is supported by the thrust ball bearings 16, 17 and 18 in side covers 19, 20 and 21. Depending on the designer's options, the thrust ball bearings 19, 20 and 21 can be replaced by plain bearings.

[0089] The compressor's intake channels A and R can be constructed in side covers 19 and 20 (channels 22 and 23), or in housing 9 (channel 24).

[0090] The engine's charging channels A_M and E can be made in the side covers 20 and 21 (channels 25 and 26), or in housing 12 (channel 27).

[0091] The ratio between the engine's unitary volume and the unitary volume of the compressor is ensured by the appropriate choice of constructive sizes of the motor and compressor.

[0092] In the case of a parallel fitting (fig. 9), shaft 28 of engine 2 is parallel to shaft 29 of compressor 1. The compressor is engaged by means of wheels 30 and 31, with a transmission 32. The transmission 32 can consist of belts, chains or gears.

[0093] The use of a transmission with a variable transfer ratio, of the type of a continuous variator with a V belt, or the use of a stage variator has benefits regarding the adjustment of the ratio between the gas flow put out by the compressor and the one consumed by the engine. The change in the compressor's speed as compared to the engine's speed provides advantages regarding the engine tuning as to reach the proposed objectives (the reduction of consumption, power increase, and so on).

[0094] Packages of two blades, 33a and 33b, (fig.12) can be used in order to improve the seal between blades 11 and housing 9 of compressor 1, as well as that between blades 14 and housing 12 of engine 2. Each blade has a bevel t_1 towards the housing, which forms a gap 33c, which acts as a seal.

[0095] Packages of two blades, 33a and 33b (fig. 12) can be used in order to improve the seal between blades 11 and side covers 19 and 20 of compressor 1, as well as that between blades 14 and covers 20 and 21 of engine 2. Each blade has towards a bevel t_1 the housing, which forms a gap 33c, which acts as a seal.

[0096] Bevel t_2 (fig.13) on a side edge of each blade 33a and 33b acts as a compensation for side clearance j, which is due to the cover and blade wear. The bevels will be placed on the edges that correspond to the contact with the side covers, so that a blade 33a will have bevel t_2 in contact with a side cover, and the other blade 33b will have bevel t_2 in contact with the other side cover.

[0097] Pressure forces which press the blades into the side covers (20 and 21) appear on the surfaces that correspond to the bevels. These bevels can be constructed on blades 11 of the compressor 1 as well.

[0098] Once the blades are into motion, the empty space under the blades, the one in channels 10, respectively 13a, changes constantly and plays the role of small pumps.

[0099] Each slot 10a of rotor 10 is connected successively to the intake channel A, or the discharge channel R, by means of two channels 34a and 34b, constructed in side covers 19 and 20 while blades 11 cross the area that corresponds to them.

[0100] Each slot 13a of rotor 13 is connected successively to intake channel A_M , or to exhaust channel E, by means of two channels 35a and 35b, made in side covers 20 and 21 while blades 14 cross the area that corresponds to them.

[0101] Channel 34a is sector-shaped and it deploys an angle φ_{AC} corresponding to channel A, while channel 34b deploys an angle φ_{RC} corresponding to channel R. The same way, the channels 35a and 35b are sector-shaped, of angles φ_D and φ_E .

[0102] Another way of using the space under the blades is by drilling 36 holes to make a connection between the channel under the blade and the chamber formed with the next blade.

Claims

1. Internal combustion rotary engine comprising of a compressor (1), which takes in air from the atmosphere through filter (7), compresses and sends it to a rotary engine (2) equipped with a fuel supply system (3), an ignition system (4), and an exhaust system (8), **characterized in that** compressor (1) is a volumetric blade rotary compressor or a cascade system consisting of either a turbocharger and a volumetric compressor, or only of a turbocharger, rotary engine (2) is a volumetric blade rotary engine, consisting of a housing (12), which holds rotor (13), which is equipped with some slots (13a), on which blades (14) are mounted. Housing (12) is built inside with a complex bore on which the blades slide, the complex bore consists of a main bore and a cylindrical secondary bore (12b) concentric with rotor (13). The space between two successive blades (e.g. 14a, 14b), the inside of the complex bore, the outer diameter of rotor (13) and the lateral side covers form a sealed chamber, during the movement of rotor (13), when the two successive blades (e.g. 14a, 14b) slide on the smaller diameter bore (12b). The volume here remains constant. When at least one of the two successive blades leaves the secondary bore (12b), the chambers' volume changes continuously, the compressed air or mixed fuel is taken in by the constant volume engine (2) chambers (a_0) and (b_0) through the engine supply channel (A_M) located in the secondary bore (12b) area. The constant volume chambers (a_0) and (b_0) go to the ignition channel (I) located in the main bore area where the chambers' volume increases and the fuel burns, the ignited gas acting with different forces upon the blades due to the difference in surfaces and thus produces useful work.
2. Internal combustion rotary engine as in Claim 1, **characterized in that** the operating cycle of the rotary engine comprises of five strokes, two strokes (intake and compression) take place in compressor (1), while three of them occur in engine (2) (transfer, ignition together with power, and exhaust). The strokes are:

Stroke 1: Intake

For the chamber formed by blades (11a), (11b), the intake begins when point (M_C) of the blade 11a crosses line (Δ_{C1}) and ends when point (M_C) of the next blade (11b) crosses line (Δ_{C2}). During this stroke, the atmospheric air fills the (a_{C1}), (a_{C2}) compressor chambers.

Intake is due to the increase in the chamber volumes formed in between two successive blades, because of the travel of the blades in the slots of rotor (10) and the subsequent increase of the R_{MC} radius.

Stroke 2: Compression

For the chamber formed of the blades (11c), (11d), the compression begins when the point (M_C) of the blade (11c) crosses line (Δ_{C3}) and ends when the point (M_C) of the next blade 11d crosses line (Δ_{C5}). During this stroke, the air is sent through compression channel (R) and gallery (6) to engine (2). The air pressure in compression channel (R) is p_c .

Compression is due to the volume decrease of the chambers formed between two successive blades, by the entrance of the rotor (10) blades and the decrease of the (R_M) radius.

Stroke 3: Transfer and Engine Intake

Engine Intake is the first stroke of the engine itself. For the engine chamber formed of the blades (14a), (14b), the engine intake begins when the point (M) of blade (14a) crosses line (Δ_1) and ends when the point (M) of the next blade (14b) crosses line (Δ_2). During this stroke, the air compressed at pressure p_c is taken in by the blade engine (2), through the engine supply channel (A_M), and transferred to the ignition channel (I). Channel (A_M) is located in the secondary bore (12b) area, and the compressed air or mixed fuel charge is achieved in the constant volume chambers (a_0) and (b_0). The fuel can be introduced into a mixing chamber (5), or directly into rotary engine (2), in the ignition chamber (formed by ignition channel I).

Stroke 4: Ignition and Power

The ignition and power takes place in engine (2) as well. For the engine chamber formed by the blades (14a), (14b), this stroke begins when point M of the blade (14a) crosses line (Δ_3) and ends when the center of mass of the chamber section passes to the right side of plane (P). The continuous movement of rotor (13) determines chamber (a_0), with mixed fuel at pressure (p_c), to reach the ignition channel (I) area. A spark produced by the

ignition system determines fuel ignition. The fuel ignition triggers an increase in pressure and gas temperature. The ignition gas acts with different forces upon the blades due to the latter's different surface. Thus, the engine produces useful work.

After the engine start and warm-up, the fuel ignition for each chamber is no longer necessary, due to the fact that ignition is transmitted. The ignition is transmitted from one chamber to the next one due to their communication through ignition channel (I).

Stroke 5: Exhaust

For the engine chamber formed by the blades (14a), (14b), this stroke begins when point M of the blade (14a) crosses line (Δ_5) and ends when point M of the next blade (14b) crosses line (Δ_6). During this stroke, the exhaust of ignited gas takes place. The chambers which exceed middle plane P and decrease their volume are connected to the exhaust channel. The gas passes from the exhaust system into the atmosphere.

3. Internal combustion rotary engine as in Claims 1 and 2, **characterized in that** in one constructive version of the invention, the mentioned complex bore consists of two cylindrical bores with parallel axes, distance between the two axes is eccentricity (e_M), the main bore (12a) has its diameter (D_M) larger than the diameter (d_M) of the secondary bore (12b) and in order to reduce the shocks, the main bore (12a) and the secondary bore (12b) may be connected with tangent lines or fillets.
4. Internal combustion rotary engine as in Claims 1 and 2, **characterized in that** in another constructive version of the invention, in order to obtain different ratios between the minimum and maximum volume of the chambers of engine (2) and to obtain desired values for angles of power and exhaust, the main bore may have a complex shape (12c), obtained by combining spline curves and/or arcs.
5. Internal combustion rotary engine as in Claims 1 to 4, **characterized in that** it is designed to run with any liquid or gaseous fuel, in one constructive version of the invention, the fuel is introduced into a mixture chamber (5) by a carburettor or in another constructive version of the invention, it is directly fed by an injector into the intake channel (A_M) or in the ignition channel (I) or anywhere in between these two channels.
6. Internal combustion rotary engine as in Claims 1 to 5, **characterized in that** it is designed to run without the need to synchronize the ignition system (4) with the rotation of the engine's shaft, because the ignition is propagated continuously from the chamber that is already burning to the next chamber, due to the fact that they communicate through the ignition channel (I).
7. Internal combustion rotary engine as in Claims 1 to 6, **characterized in that** the compressor (1) can be mounted coaxially to the rotary engine (2), the shaft (15) supports both the rotor (10) of the compressor (1) and the rotor (13) of the engine (2), the shaft (15) is supported by thrust ball bearings or plain bearings (16), (17) and (18) mounted in lateral side covers (19), (20) and (21).
8. Internal combustion rotary engine as in Claims 1 to 6, **characterized in that**, the compressor (1) can be mounted parallel to the rotary engine (2), the shaft (28) of engine (2) is parallel to the shaft (29) of compressor (1) and compressor (1) is driven by a transmission (32) that consists of belts, chains or gears.
9. Internal combustion rotary engine as in Claim 8, **characterized in that** in the case of a parallel mounting, a transmission (32) with a variable transfer ratio, continuous or step variator may be used, that grants benefits regarding the adjustment of the ratio between the gas flow put out by the compressor (1) and the one taken in by the engine (2).
10. Internal combustion rotary engine as in Claims 1 and 2, **characterized in that** the compressor's charging channels (A) and (R) can be built in the side covers (19) and (20) in the position of channels (22) and (23), or in housing (9) in the position of channel (24) and the engine's charging channels (A_M), (I) and (E) can be built in the side covers (20) and (21), in the position of channels (25) and (26), or in housing (12) in the position of channel (27).
11. Internal combustion rotary engine as in Claims 1 and 2, **characterized in that** in order to improve the seal between blades (11) and the compressor housing (9), as well as that between blades (14) and the engine housing (12), packages of two blades (33a) and (33b), each blade having towards the housing a bevel (t_1) which forms an empty space (33c), which acts as a seal, can be used.
12. Internal combustion rotary engine as in Claims 1, 2 and 11, **characterized in that** in order to improve the seal between the blades (11) and the compressor side covers (19) and (20), as well as that between blades (14) and

the side covers (20) and (21) of the engine (2), each blade has towards a side cover a bevel (t_2) that will be placed on edges that correspond to the contact with the side covers, so that a blade (33a) will have bevel (t_2) in contact with a side cover, and the other blade (33b) will have bevel (t_2) in contact with the other side cover. The pressure forces which appear on the bevel surfaces act as a compensation for the clearance (j), which is due to blade wear.

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13. Internal combustion rotary engine as in Claims 1 and 2, **characterized in that** each slot (10a) of the rotor (10) of the compressor (1) is connected successively to the intake channel (A), or the discharge channel (R) while the blades (11) cross the area that corresponds to them, by means of two channels (34a) and (34b), built in the side covers (19) and (20). Channel 34a is sector-shaped and it covers the angle φ_{AC} corresponding to channel A, while channel 34b covers the angle φ_{RC} corresponding to channel R.
14. Internal combustion rotary engine as in Claims 1 and 2, **characterized in that** each slot (13a) of the rotor (13) of the engine (2) is connected successively to the intake channel (A_M), or the exhaust channel (E) while the blades (14) cross the area that corresponds to them, by means of two channels (35a) and (35b), made in the side covers (20) and (21). Channel 35a is sector-shaped and it covers the angle ($\varnothing_D$), while channel (35b) covers the angle corresponding to exhaust channel (E).
15. Internal combustion rotary engine as in Claims 1 and 2, **characterized in that** for a proper operation of compressor (1), the value of the angle of the beginning of the intake delay (φ_{AC1}) is determined from the condition of near pressures between the chamber that is just coming into contact with the intake channel and the intake channel A itself, and the value of the angle of the beginning of the discharge delay (φ_{RC1}) is determined from the condition of near pressures between the chamber that is just coming into contact with the exhaust channel and the discharge channel itself.

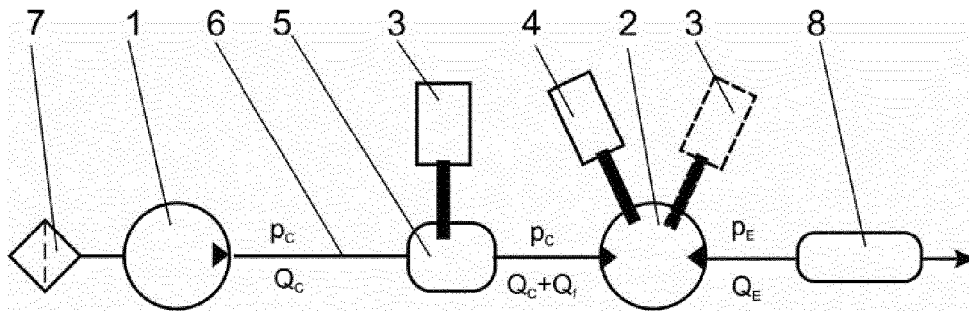


Figure 1

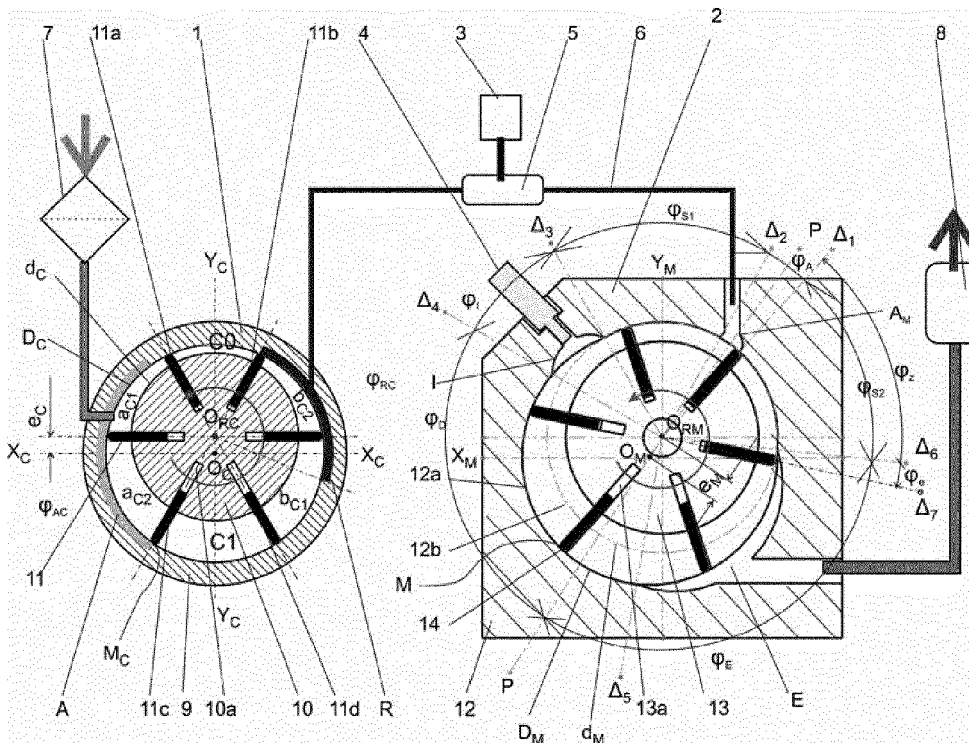


Figure 2

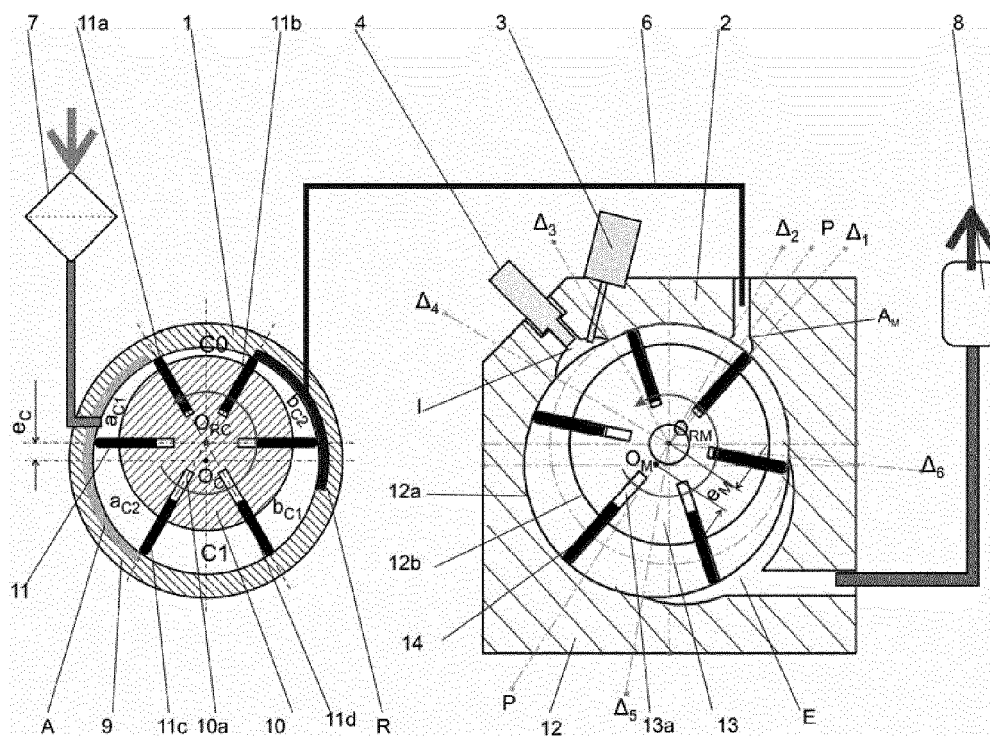


Figure 3

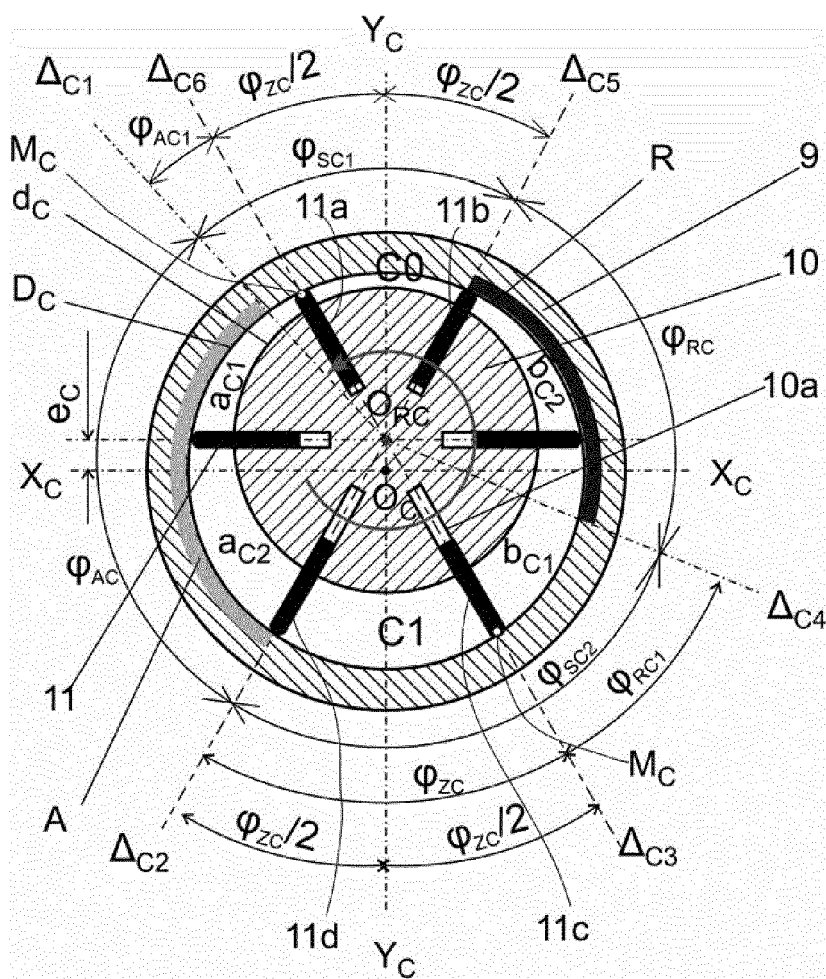


Figure 4

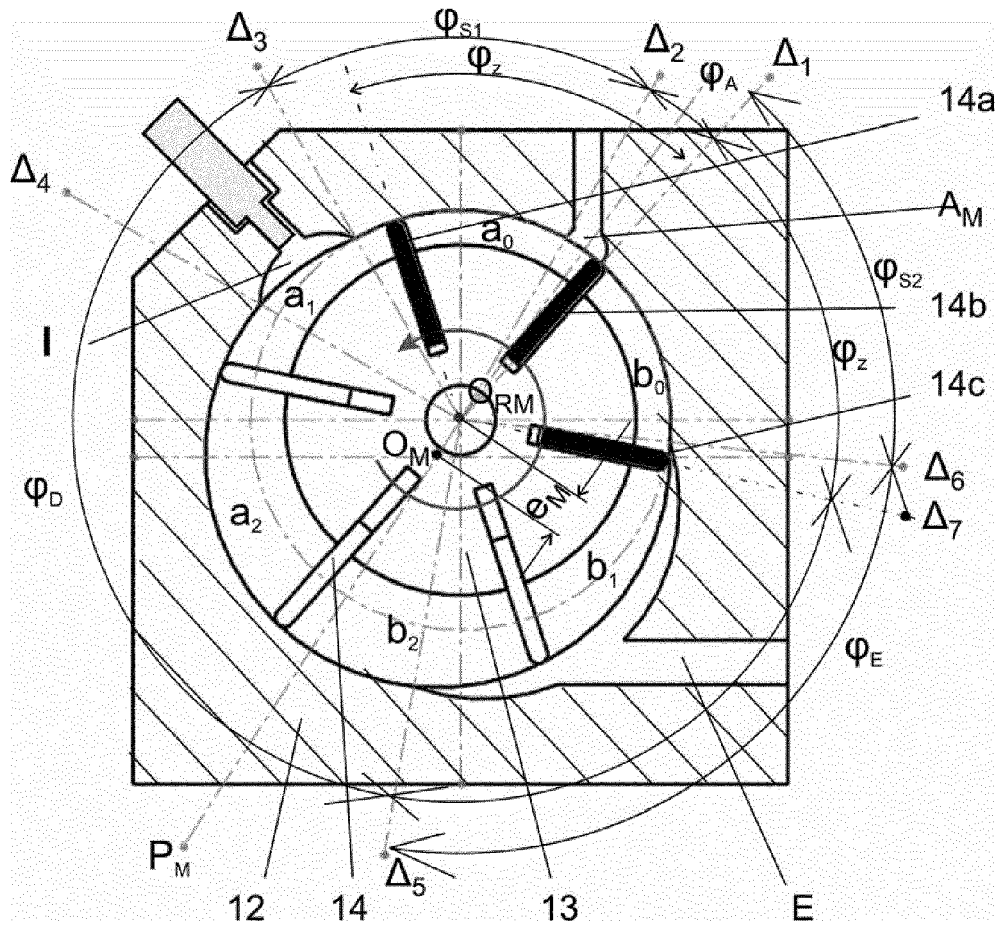


Figure 5

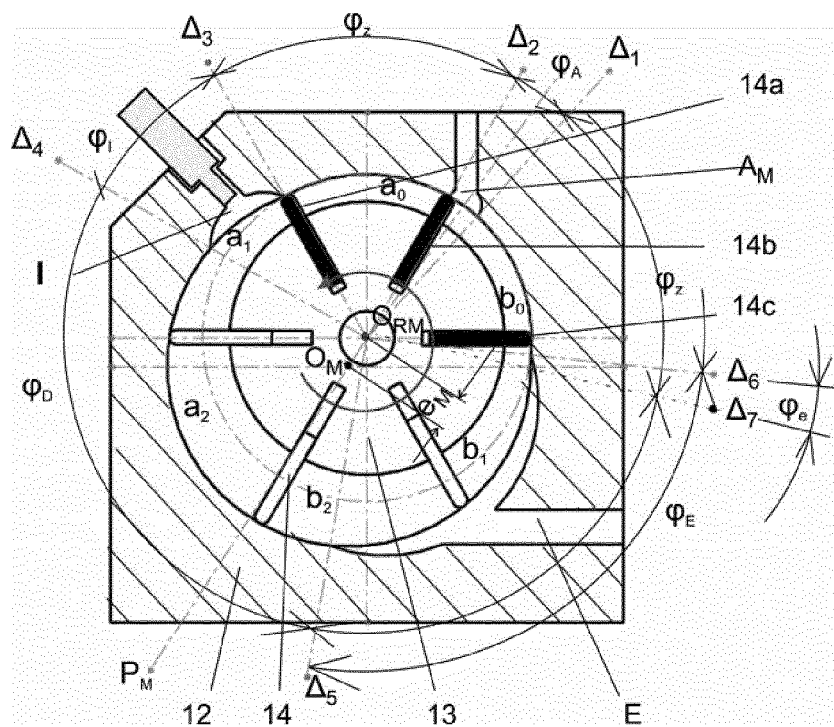


Figure 6

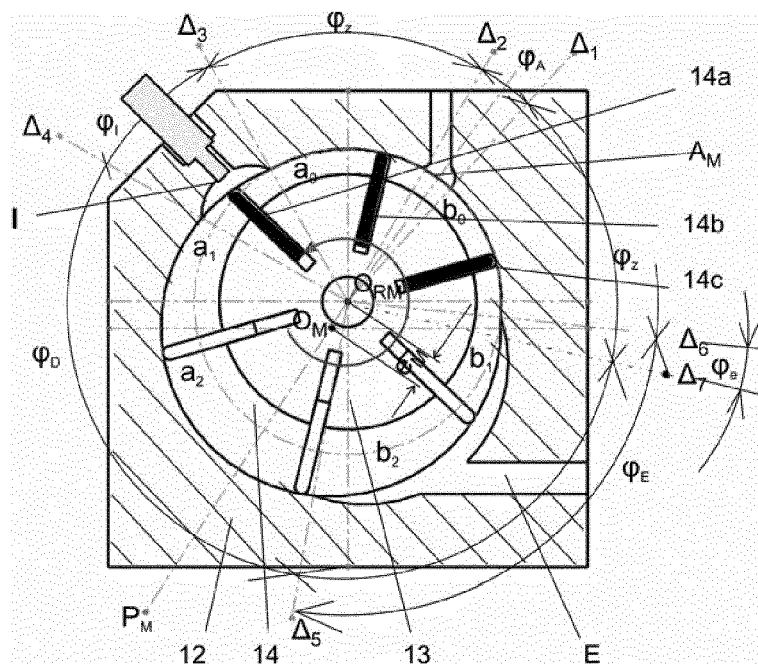


Figure 7

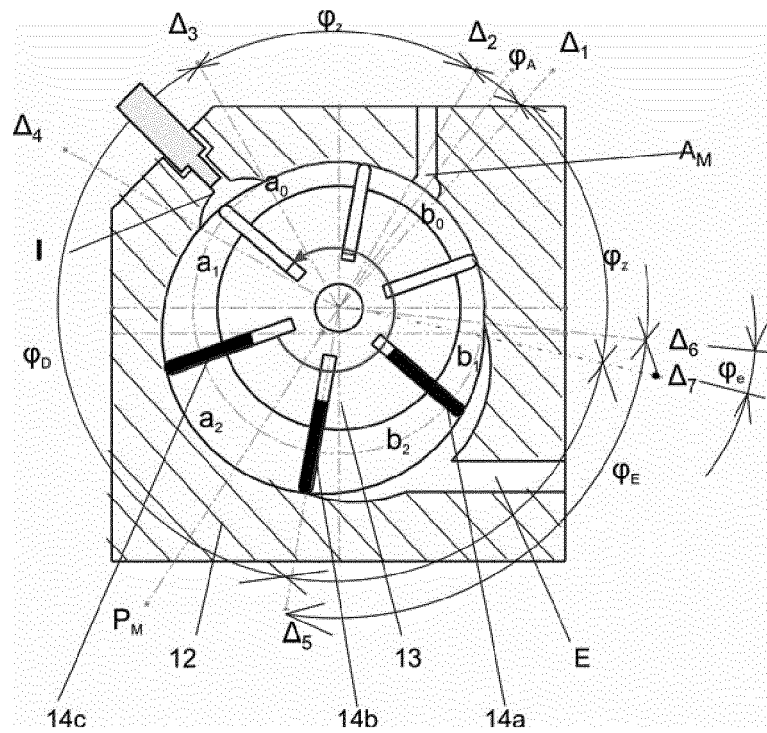


Figure 8

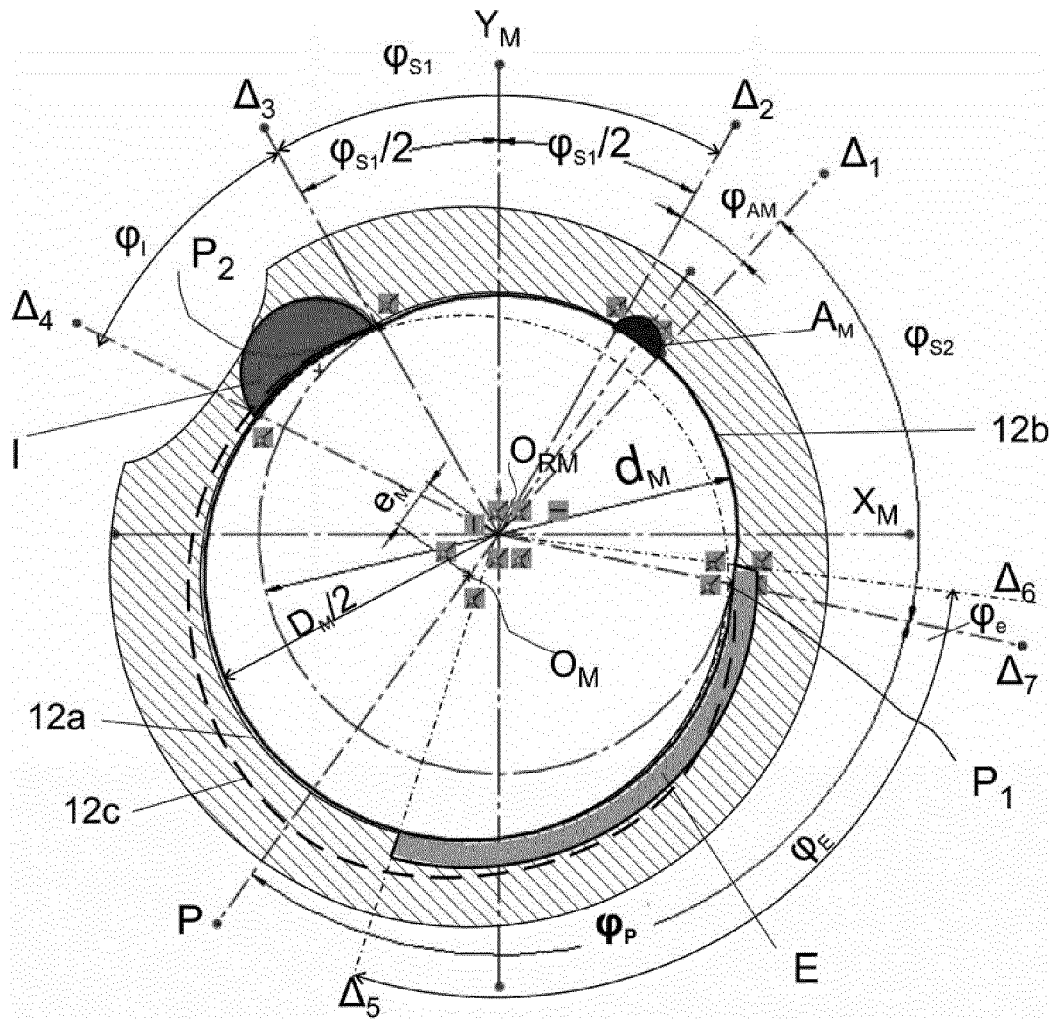


Figure 9

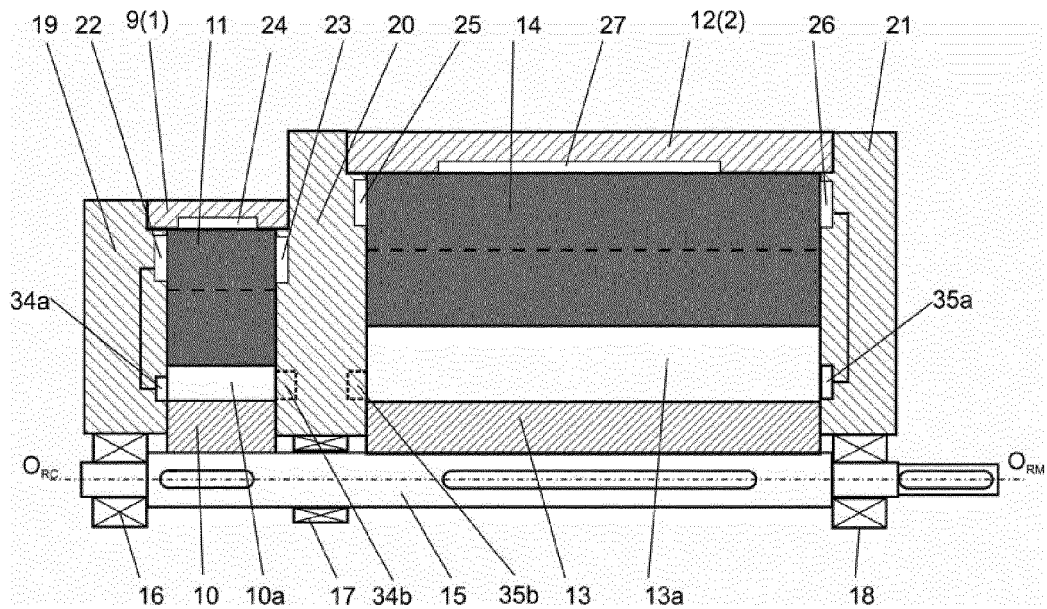


Figure 10

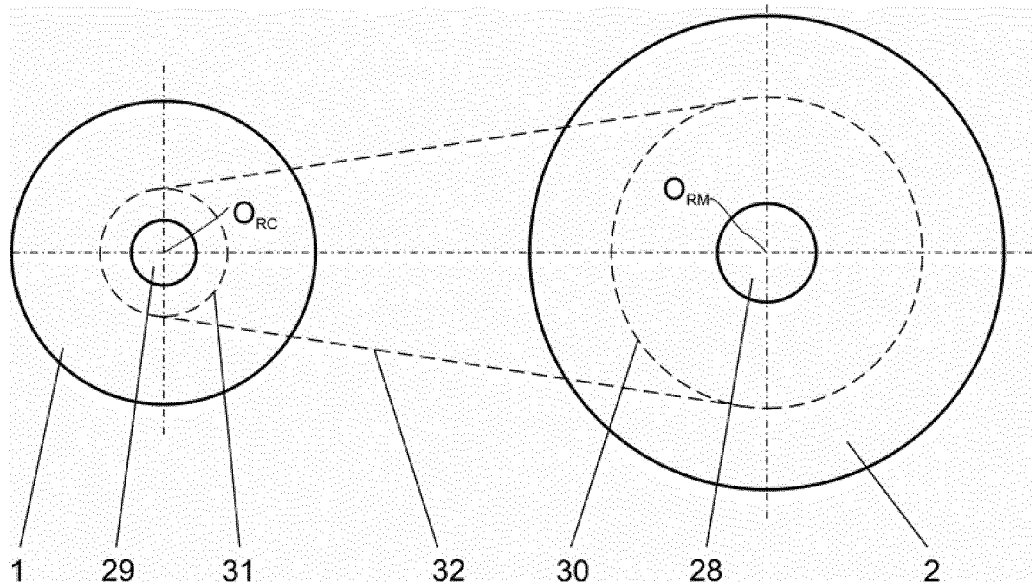


Figure 11

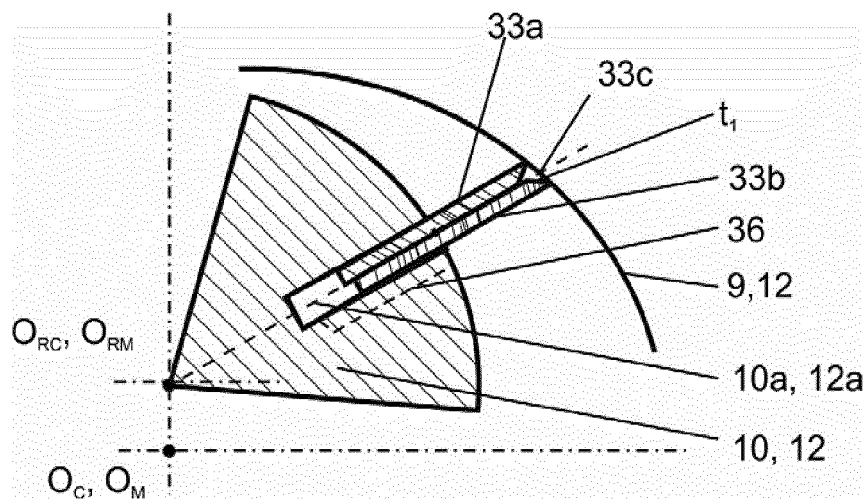


Figure 12

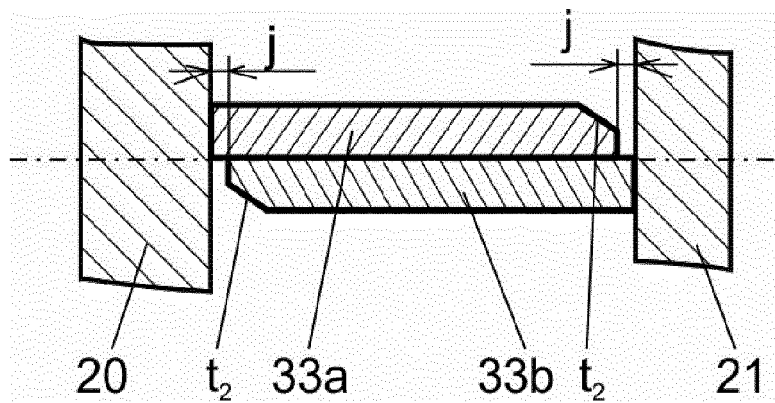


Figure 13



EUROPEAN SEARCH REPORT

Application Number
EP 13 15 3780

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	US 4 422 419 A (UMEDA SOEI [JP]) 27 December 1983 (1983-12-27) * column 2, line 36 - column 4, line 56 * * figures 1-12 *	1-15	INV. F01C11/00 F01C1/344 F01C21/10
X	US 2005/005898 A1 (HORSTIN ABRAHAM HUGO [US]) 13 January 2005 (2005-01-13) * paragraph [0017] - paragraph [0025] * * paragraph [0036] * * paragraph [0053] - paragraph [0058]; figures 1, 2a-3c *	1-15	
X	DE 20 2006 004847 U1 (TEVKUER TALIP [DE]) 22 June 2006 (2006-06-22) * paragraph [0023] - paragraph [0042]; figure 1 *	1-15	
A	EP 1 666 707 A1 (SHARUDENKO ANDREY YURYEVICH [RU]; SHARUDENKO OLGA MIKHAYLOVNA [RU]) 7 June 2006 (2006-06-07) * paragraph [0006] - paragraph [0036] * * paragraph [0065] - paragraph [0078]; figure 28 *	1-15	TECHNICAL FIELDS SEARCHED (IPC)
A	DE 24 14 465 A1 (FESTO MASCHF STOLL G) 16 October 1975 (1975-10-16) * page 5, last paragraph - page 8, paragraph 1; figure 1 *	1-15	F01C F04C
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 18 July 2013	Examiner Papastefanou, M
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 13 15 3780

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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18-07-2013

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4422419 A	27-12-1983	JP S5656903 A	19-05-1981
		JP S6239252 B2	21-08-1987
		US 4422419 A	27-12-1983

US 2005005898 A1	13-01-2005	NONE	

DE 202006004847 U1	22-06-2006	NONE	

EP 1666707 A1	07-06-2006	AU 2003304463 A1	29-03-2005
		EP 1666707 A1	07-06-2006
		RU 2241129 C1	27-11-2004
		US 2006204392 A1	14-09-2006
		WO 2005024203 A1	17-03-2005

DE 2414465 A1	16-10-1975	NONE	

EPO FORM P0459

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

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 3359954 A [0004]
- US 2988065 A [0004]
- US 4490101 A [0004]
- EP 0337950 A [0004]
- US 7556015 B [0006]