

Jan. 27, 1959

Y. L. G. BREELLE  
ROTARY ENGINES

2,870,752

Filed Nov. 14, 1957

4 Sheets-Sheet 1

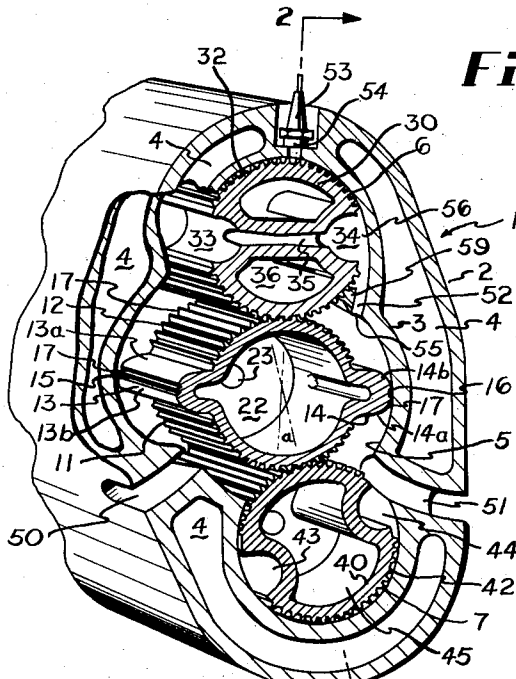


Fig. 1

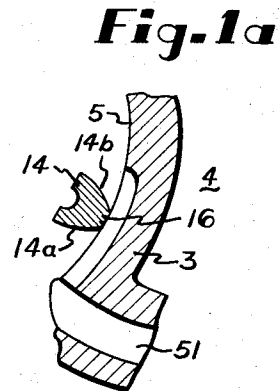


Fig. 1a

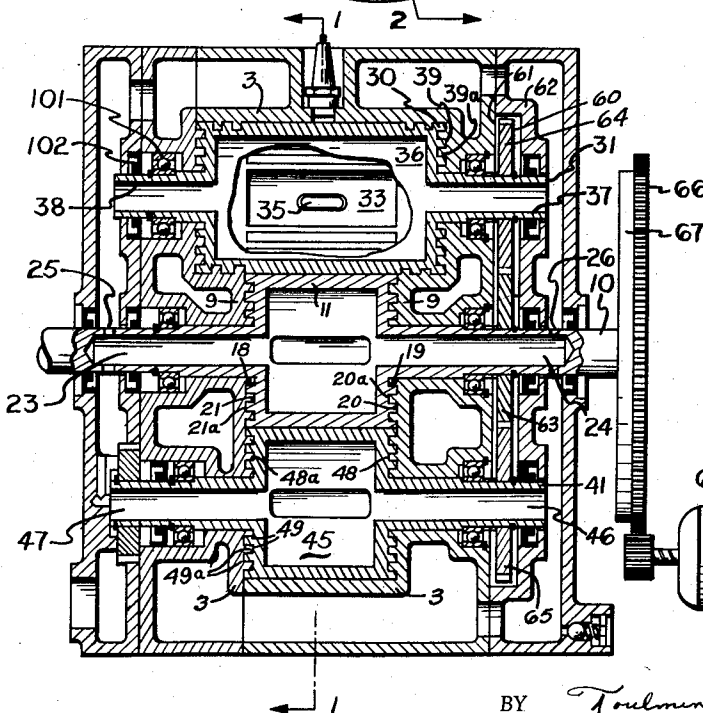


Fig. 2

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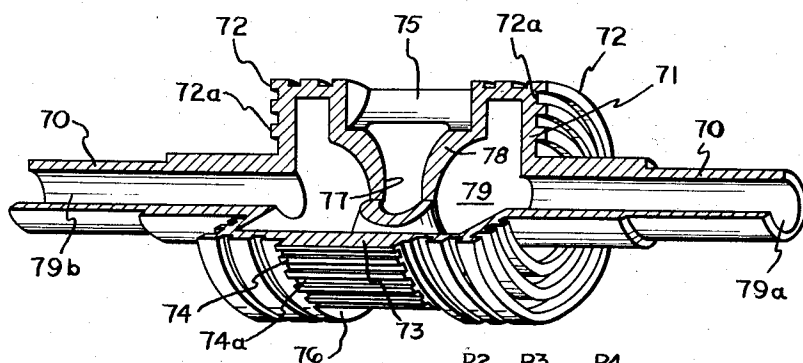
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ROTARY ENGINES

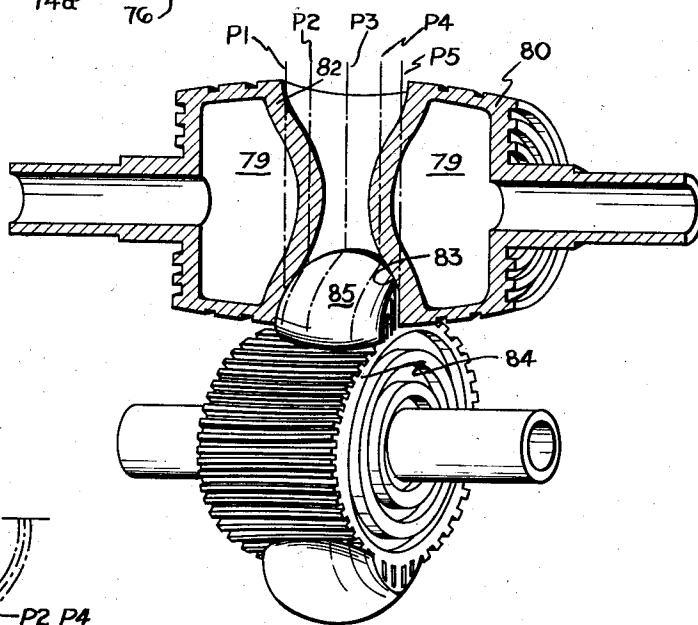
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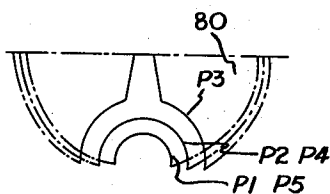
**Fig. 3**



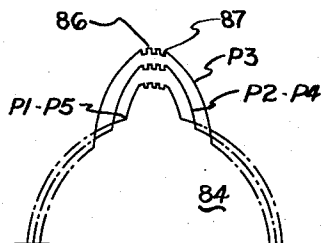
**Fig. 4**



**Fig. 5a**



**Fig. 5b**



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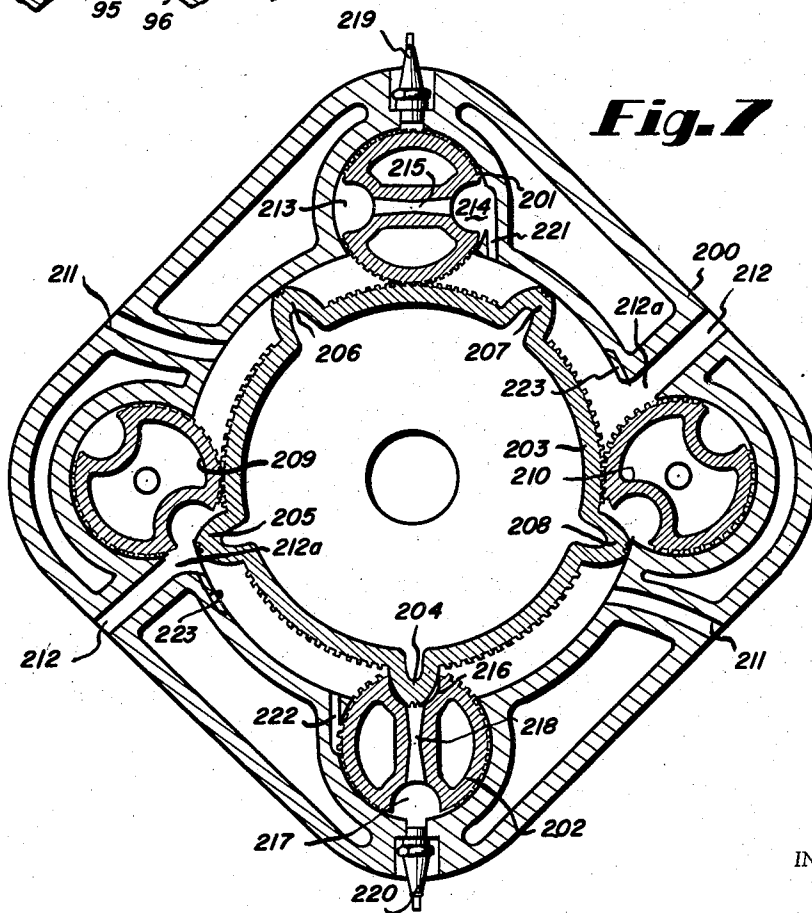
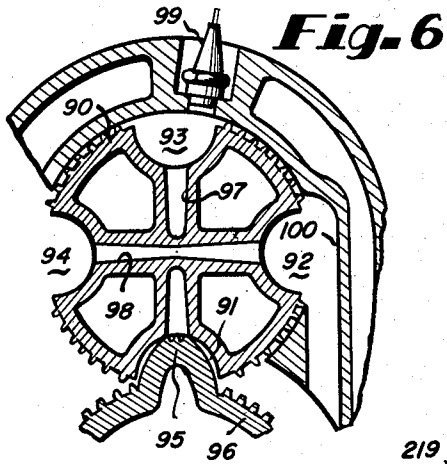
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## ROTARY ENGINES

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Application November 14, 1957, Serial No. 696,538

Claims priority, application France November 14, 1956

16 Claims. (Cl. 123—13)

This invention relates to improvements in rotary engines, and more particularly in such engines comprising internal combustion rotors.

It is an object of my invention to provide improvements in rotary engines having rotary internal combustion means, whereby the cooling and scavenging of the engine during its operation is greatly improved.

It is a further object of my invention to provide an improved rotary engine comprising rotary internal combustion means, which engine is of simpler construction, with those parts to be exchanged with relative frequency, being much easier to assemble and more easily accessible than in the known constructions.

The improvements in rotary engines according to this invention are particularly suited for use with rotary engines comprising internal combustion rotors, which engines are described in my patent application Serial Number 574,833, filed on March 29, 1956, and the continuation-in-part application thereof, filed on October 8, 1957, under Serial Number 688,908.

In all those rotary engines having rotary internal combustion means, which are at present known in the art, a main problem that has to be solved is that of non-uniform thermal expansion and contraction of the rotary elements in the casing. These rotary elements normally comprise considerable compact metallic masses, and it has been difficult to prevent uneven expansion at the high temperatures to which these masses are temporarily exposed, and uneven cooling down thereof at intervals of lower temperature. These uneven changes lead to deformations of the rotor bodies and correspondingly to either binding effects or deterioration of the bearing and sealing means of the rotary elements, and consequently shorten the life time of these engines.

While the choice of expensive alloy materials having small thermal expansion coefficients may offer at least a partial solution to that problem, I have invented improvements in the structure, in particular of the rotary elements of rotary internal combustion engines, which largely eliminate the above described drawbacks and permit to attain the objects stated hereinbefore.

The improved rotary engine with rotary internal combustion means, according to my invention, comprises, as a main feature, at least one internal combustion rotor provided with recesses or "wells" for the passage therethrough of the rotary pistons of the central rotor characteristic of rotary engines, which wells serve at the same time as the combustion chambers proper of the internal combustion rotor.

As a further important feature, these several chambers, hereinafter referred to for the sake of brevity as "wells," are interconnected by internal channel or conduit means provided in the combustion rotor so as to constitute a single combustion space.

Furthermore, in order to ensure the above mentioned important uniformity of thermal dimensional changes of the combustion rotor, these channel or conduit means

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are disposed symmetrically to the central axis of the combustion rotor.

As a further important feature of the invention, the wells in the combustion rotor being interconnected with each other by the aforesaid conduit means are so coordinated in their function with the remaining rotary elements of the rotary engine, that after each combustion and power stroke or period, the end of the compression period involving the charge of the wells with a new fuel mixture prior to combustion coincides with a scavenging of the entire combustion space from which residual gases are expelled by the newly introduced gases. At the same time, losses due to fresh gases escaping directly through the exhaust means of the engine are maintained at a minimum. One or several pairs of wells may be provided in the combustion rotor, the two wells of each pair being disposed preferably diametrically relative to each other and connected by a channel extending substantially transversely to the rotor axis. The wells of each pair may also be disposed adjacent each other and connected by a channel through the interior of the rotor.

The combination of the aforesaid features of the invention in the internal combustion rotor contributes to a most effective cooling of the latter in a uniform manner, due firstly to (a) the limitation of the combustion space to wells and interconnecting conduits, (b) the geometrically symmetrical arrangement of the combustion space in the rotor body, (c) sufficient space left in the rotor body for large cooling cavities and/or conduits, and (d) contribution of the scavenging step in the rotor to a uniform cooling of the latter by the fresh combustion gases.

In a preferred embodiment of the invention, the improved rotary engine according to my invention comprises a combustion rotor having the above defined characteristics, and a central rotor bearing a determined number  $n$  of "pistons" or large protrusions in the cylindrical wall of the rotor, which are distributed about the shaft of the central rotor spaced from each other under an angle of

$$\frac{360^\circ}{n}$$

and at least one sealing rotor in an engine block or casing provided with the necessary means for synchronising the movement of the various rotors, intake and exhaust means associated with, and conduits provided in the casing.

This type of engine is described in detail in my patent application and continuation-in-part application supra.

In the same manner, my improved rotary engine may comprise two or more internal combustion rotors embodying the above described characteristic features.

Each of the combustion rotors may be provided with a number of  $2e$  combustion wells distributed about the central axis of the combustion rotor under an angle of

$$\frac{360^\circ}{2e}$$

relative to each other.

And each gate rotor may be provided with a number of  $p$  gate or valve wells distributed about the central axis of the gate rotor under an angle of

$$\frac{360^\circ}{p}$$

relative to each other.

Furthermore, the improved rotary engine according to my invention may comprise a central rotor bearing a plurality of pistons distributed irregularly about the periphery of the central rotor, while the wells in the peripheral rotors, i. e. the internal combustion rotor of

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rotors and the gate rotor or rotors, are correspondingly disposed irregularly about the peripheries of their respective rotors so as to permit passage of the pistons there-through during the rotation of the central rotor.

However, the above mentioned regular distribution of pistons about the periphery of the central rotor is preferred since it permits a better balancing of the latter, and consequently also of the peripheral rotors.

Thus, the central rotor and the peripheral rotors are preferably of the types described in my patent application and continuation-in-part application supra.

The invention will be better understood from the subsequent detailed description thereof in connection with the accompanying drawings in which:

Figure 1 is a vertical transverse sectional view through a rotary engine constructed in accordance with the invention, the section being taken along line I—I in Figure 2;

Figure 1a shows a partial sectional view of the exhaust region shown in Figure 1, having a somewhat different structure;

Figure 2 is a vertical longitudinal sectional view of the rotary engine shown in Figure 1 along line II—II therein;

Figure 3 is a perspective, partially sectional view of one embodiment of a combustion rotor according to the invention;

Figure 4 illustrates in perspective and partially in section another embodiment of a combustion rotor and a corresponding central rotor in accordance with the invention;

Figures 5a and 5b show contour lines in different transverse planes of a well of the combustion rotor, and of a piston of the central rotor, respectively, which are both illustrated in Figure 4;

Figure 6 illustrates yet another embodiment of a combustion rotor according to the invention in cross-sectional view;

Figure 7 is a vertical transverse sectional view of another embodiment of a rotary engine constructed in accordance with the invention, which engine comprises two combustion rotors and a central rotor bearing five pistons;

Figures 8a and 8e illustrate schematically five different positions of the combustion rotor, the central rotor and the gate rotor of the rotary engine illustrated in Figures 1 and 2.

Referring now to the drawings more in detail, and in particular to Figures 1 and 2, which represent a simple embodiment of the improved rotary engine according to the invention, the engine block or casing 1 is provided with an external wall 2 and internal wall 3 and a plurality of cooling spaces 4 intermediate these walls.

The inner wall 3 encloses a central substantially cylindrical space defined by the internal cylinder surface 5 and peripherally disposed relative to the aforesaid cylinder space, two cylindrical spaces or cavities defined by internal surface portions 6 and 7 of the inner wall 3. The central axes of the latter two cylindrical spaces extend parallel to the central axis of the aforesaid cylinder space.

In the central axis of the latter space, there extends a main engine shaft 10 on which there is mounted a central rotor 11. This central rotor 11 bears along its external cylindrical surface 12 two rib-shaped pistons 13 and 14 disposed on opposite sides of the central rotor 11 and extending parallel to the central axis of the latter.

The pistons 13 and 14 are preferably of a cross-section similar to that of the teeth of a gear and their exact contours are determined as described in my copending patent application Serial No. 688,908 supra. Due to the rotation of the central rotor 11 which shall be assumed to be always in clockwise direction, leading slopes 13a, 14a, and trailing slopes 13b, 14b of pistons 13 and 14 can be distinguished. The end surfaces 15 and 16 of these pistons are preferably provided with longitudi-

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nally extending grooves and ribs 17. Similar longitudinal ribs and grooves 17 are also provided about the cylindrical surface 12 of central rotor 11. The end faces 18 and 19 of the central rotor 11 may be provided with annular protrusions 20 and grooves 20a, while the portions 9 of the internal surface of inner wall 3 facing these rotor end faces 18 and 19 bear similar protrusions 21 fitting into the grooves 20a of rotor 11, while the protrusions 20 of the latter protrude into similar grooves 21a intermediate protrusions 21. The protrusions and grooves 20, 20a of rotor 11 on the one hand, and protrusions and grooves 21, 21a of wall 3 on the other hand, are so disposed that there is no friction between them, the arrangement providing, however, for a labyrinth-type sealing effect between the rotor 11 and surface 5 of wall 3.

The interior of rotor 11 comprises cooling spaces 22 which are accessible to the flow of a coolant there-through, for instance, by way of passages 23 and 24 opening into transverse channels 25 and 26 in rotor shaft 10.

In the cylindrical cavity defined by wall surface 6 there is housed a combustion rotor 30 mounted on combustion rotor shaft 31. The outer cylindrical surface of rotor 30 is covered with longitudinal ribs and grooves 32 meshing with those ribs and grooves 17 provided on the external wall 12 of rotor 11 in such a manner that no friction is caused during the rotation of both rotors, while a labyrinth-type sealing effect is created between both rotors which effectively prevents the escape of fluid from one to the other side of the central rotor chamber through between the two rotors 11 and 30.

The combustion rotor 30 is provided with two recesses or wells 33 and 34, each extending axially along one side of the cylindrical surface of rotor 30 and opposite the other well. The wells 33 and 34 are so disposed on rotor 30 that they allow for passage therethrough of pistons 13 and 14 of the central rotor 11.

Instead of possessing separate internal combustion chambers in the interior of the rotor 30 as does the corresponding rotor in my copending patent application Serial No. 688,908 supra, the rotor 30 is provided, in accordance with the present invention, with a diametrically extending channel or conduit 35 connecting the two wells 33 and 34. Conduit 35 may preferably have a narrower cross section at the center of rotor 30 than when it opens into wells 33 and 34. Wells 33 and 34 together with conduit 35 constitute the combustion chamber in rotor 30, thus leaving sufficient space available in the interior of rotor 30 for cooling chamber 36. Coolant is circulated through the latter via coolant passages 37 and 38.

The end surfaces of rotor 30 are provided with annular protrusion and groove means 39 similar to those borne by rotor 11 and coact in a similar manner with corresponding protrusions 39a to achieve the same labyrinth-type sealing effect with surface 9 of wall 3.

The other cavity substantially opposite that cavity which houses the combustion rotor, and defined by cylindrical surface 7 of inner wall 3 of the casing 1 houses a rotary abutment or "sealing rotor" 40, which is mounted on a gate rotor shaft 41 and is provided on its external cylindrical surface with ribs and grooves 42 engaging with ribs and grooves 17 on surface 12 of rotor 11 to attain a labyrinth-type sealing effect as mentioned above between rotors 11 and 40.

Gate recesses, or wells, 43 and 44 are provided in the cylindrical surface of gate rotor 40 at diametrically opposite sides of the rotor. Pistons 13 and 14 of central rotor 11 pass successively through these wells 43 and 44 during the rotation of both rotors 11 and 40. The interior of rotor 40 comprises a cooling space 45 through which coolant circulates via conduits 46 and 47. The end faces 48, 48a of rotor 40 are provided with annular protrusions and groove means 49 which engage corresponding means 49a in surface 9 of inner casing wall 3.

to produce a labyrinth-like, friction-free sealing effect between rotor 40 and the wall 3 of the casing.

In the latter wall 3, there are further provided an intake conduit 50 and an exhaust conduit 51 leading from the internal space housing the central rotor to the outside of external wall 2 of engine casing 1.

Furthermore, a transfer or bypass conduit 52 is provided in wall 3, which conduit leads from the opening 55 in the wall surface 5 of the space housing the central rotor 11 behind a wall portion 59 to the surface 6 of wall 3 defining the cavity which houses combustion rotor 30 and opens into that cavity with a broad mouth 56. This bypass conduit 52 is located on the side where the cylindrical surfaces of rotors 11 and 30 separate, clockwise rotation of rotor 11 being assumed.

In the embodiment of the rotary engine illustrated in Figures 1 and 2 the shaft 41 of sealing rotor 40 is parallel to shafts 10 and 31, but the geometrical plane defined by shafts 10 and 31 forms an angle  $\alpha$  with geometrical plane defined by shafts 10 and 41. This arrangement has certain advantages to be described further below.

At the top end of casing 1, a spark plug 53 is located in a bore 54 which opens into the internal wall surface 6 of the cavity housing the combustion rotor at some distance from the opening of conduit 52 therein. It is preferably slightly displaced from the geometrical plane defined by shafts 31 and 10, in a direction to obtain ignition briefly prior to the piston reaching dead center position.

In an outer compartment 60 of casing 1, which is formed by walls 61 and 62, a gear train comprising gears 63 on shaft 10, 64 on shaft 31 and 65 on shaft 41 effects the rotation in harmony of rotors 11, 30 and 40.

Outside the casing 1, shaft 10 bears a ring gear 66 on the flywheel 67 connected in the usual way to the starting motor 68.

The external piping for fuel and/or air intake and exhaust of waste gases, as well as for the admittance and withdrawal of coolant, are well known in the art and omitted for the sake of clarity.

Figure 3 shows an embodiment of an internal combustion rotor for rotary engines in accordance with my invention, in which reference numeral 70 designates the combustion rotor shaft. The rotor body which is rigidly mounted on this shaft 70 comprises a head or end surface 71 bearing annular protrusions 72 and grooves 72a for effecting a labyrinth-type sealing with the adjacent wall of the engine casing, and a cylindrical mantle wall 73 which bears over that portion of its external surface which cooperates with the central rotor of the rotary engine, a plurality of ribs 74 and grooves 74a to achieve a labyrinth-type sealing effect between the two rotors along their line of contact.

In the wall 73, there are provided at opposite sides of that wall, in diametrical position to each other, piston wells 75 and 76 which are of rectangular longitudinal cross section, i. e. that cross section which is taken in a plane parallel to the central rotor axis, and is of substantially rectangular cross section in a plane radial to the rotor axis.

A channel 77 of trumpet-shaped cross section connects wells 75 and 76 freely communicating with each other. This channel 77 is preferably of approximately elliptic cross section taken in planes perpendicular to the central longitudinal axis of the channel. Channel 77 is enclosed by internal tubular wall 78 which is so devised that the narrowest cross section of the channel 77 is at the point where the channel traverses the rotor axis, while the largest cross sections are located where channel 77 opens into wells 75 and 76.

The remaining internal space of the rotor forms a cooling chamber 79 through which a coolant is circulated via conduit 79a in shaft 70, and via an axial outlet opening 79b.

Another embodiment of the combustion rotor for rotary engines in accordance with the invention is illustrated in Figure 4. The body 80 of the internal combustion rotor in Figure 4 is of approximately ellipsoid shape except in the planes passing through the rotor axis and in which the piston wells 82 and 83 are located with their central cross section, and comprises otherwise the same structure as the rotor illustrated in Figure 3.

However, wells 82 and 83 are of a concave shape rather than of the rectangular box shape in Figure 3.

Correspondingly the central rotor 84 cooperates with combustion rotor 80 and is of a shape which is concavely complementary to the approximately ellipsoid shape of the latter. Of course, it is also possible to provide a central rotor having an approximately ellipsoid body, and a concavely complementary shape of the combustion rotor. The central rotor 84 bears pistons 85, only one of which is shown in Figure 4. The pistons 85 are of frusto ellipsoidal shape so as to pass as snugly as possible through the wells 82 and 83.

Figure 5a illustrates the cross sectional contours of rotor 80 and one of the wells 82, 83 taken in planes  $P_1$ ,  $P_2$ ,  $P_3$ ,  $P_4$  and  $P_5$  as indicated by dash-dotted lines in Figure 4, while Figure 5b illustrates rotor 84 and the contour lines of the cross sections of one of pistons 85 taken in the same aforesaid planes.

This preferred embodiment of the wells and pistons of the rotary engine in accordance with the invention comprising convex pistons and concave wells has the advantage that, as the wells represent the combustion chambers in the combustion rotor in accordance with this invention, the front of the combustion flame is better propagated therein, in front of the pistons, than it is in wells and by pistons of known design.

The transverse profile of the pistons as it is shown in Figure 5b preferably comprises a flattened ridge 86 which contributes to an improved sealing effect. The latter may be further increased by providing ribs and grooves 87 extending longitudinally along the ridge 86.

In a further embodiment of the combustion rotor in accordance with the invention as illustrated in Figure 6, the rotor body 90 comprises four piston wells 91, 92, 93 and 94 through which pass the pistons 95 of a central rotor 96. Piston wells 91 and 93 freely communicate with each other by way of a conduit 97 disposed diametrically in rotor 90, whereby these wells 91, 93 and conduit 97 form a first combustion space; wells 92 and 94, on the other hand, are freely communicatingly connected by a conduit 98 disposed at right angle to conduit 97 and bypassing the latter on a different plane transverse to the rotor axis, and thus forming in conjunction with the latter conduit a second combustion space.

A single spark plug 99 may be substantially provided opposite the line of contact between rotors 90 and 96, and a bypass conduit 100 opening through the surrounding wall of the engine casing is disposed in a position similar to that shown in Figure 1.

In this embodiment, central rotor 96 may be provided with more than two pistons as has been set forth in my co-pending applications Ser. Nos. 574,833 and 688,908 supra.

Instead of being diametrically connected by conduits as illustrated in Figure 6, pairs of wells may be disposed next adjacent each other and connected by conduits passing through the interior of the rotor body in such a manner that the combustion spaces formed by each pair of wells and its connecting channel are disposed substantially parallel to each other in the rotor body. In this system, two spark plugs must be provided in the vicinity of the horizontal plane through the rotor axis, which plane extends perpendicularly to the plane common to the central axes of the combustion rotor and the central rotor. A plurality of bypass channels open into the cavity housing the combustion rotor in the vicinity of the aforesaid plane at opposite sides of the last-mentioned

rotor and communicate both freely with the central space of the engine housing the central rotor in the region of the power zone.

The combustion rotors in accordance with the invention and described hereinbefore may also be used in rotary engines other than that shown in Figures 1 and 2. For instance, the different kinds of rotary engines disclosed in my co-pending patent applications Ser. Nos. 574,833 and 688,908 supra can easily be fitted out with these combustion rotors. As only one example of such use, Figure 7 illustrates a rotary engine comprising a casing 200 and two combustion rotors 201 and 202 therein, of the type illustrated in Figure 1, cooperating with a central rotor 203 which bears on its periphery five pistons 204, 205, 206, 207 and 208. The engine further comprises two gate rotors 209, 210 arranged about the central rotor 203 alternately with combustion rotors 201 and 202, and intake conduits 211 and exhaust conduits 212. The combustion rotor 201 is provided with two wells 213 and 214 and a diametrically disposed connecting channel 215, while rotor 202 is provided similarly with wells 216 and 217 and a connecting channel 218. Each of the rotors further cooperates with a spark plug 219, 220, and a bypass conduit 221, 222 respectively, which spark plugs and bypass conduits are provided in the engine casing 200.

In order to guarantee a more complete scavenging of the combustion space constituted by, for instance, the wells 213 and 214 and connecting channel 215, the portion of the space housing the central rotor 203 between the contact line of the latter with rotor 201 and the trailing edge of the departing piston 207 is preferably brought into connection with the exhaust conduit, for instance, 212, somewhat before access thereto is opened by piston 207 passing the mouth 212a of that conduit. This is achieved by recesses 223 in the wall enclosing the internal chamber of the casing 200 housing the central rotor 203. A similar recess may, of course, be provided in the wall 3 of the rotary engine illustrated in Figure 1, as is shown in the partial view of the exhaust region thereof, shown in Figure 1a.

#### Operation

The operation of a rotary engine comprising an internal combustion rotor or rotors in accordance with my invention shall be explained in detail, at the hand of the embodiment of my invention illustrated in Figures 1 and 2, five successive stages in the operation of this engine being schematically shown in Figures 8a to 8e.

It will be understood that the basic operation of the embodiment of a rotary engine shown in these figures applies equally to the functioning of the rotary engine illustrated in Figure 7 and to all similar rotary engines provided with internal combustion rotors in accordance with my invention.

In Figures 8a to 8b like reference numerals indicate like parts as in Figures 1 and 2.

The central rotor 11 is set in motion with the aid of auxiliary starting motor 68 (Figure 2), for instance, a small electromotor, so that it rotates clockwise as indicated by arrows in Figures 8a to 8e. The pistons 13 and 14 of central rotor 11, and the wall of the latter where it contacts the walls of rotors 30 and 40, subdivides the cylindrical central chamber enclosed by wall surface 5 into 4 zones of varying volume:

(1) An intake or aspiration zone A between the contact line of rotors 11 and 40 and the trailing slope 13b or 14b of either piston 13 or 14,

(2) A compression zone C intermediate the leading slope (13a or 14a) of either piston 13 or 14 and the contact line between rotors 11 and 30,

(3) An expansion or power zone P intermediate the contact line between rotors 11 and 30 and the trailing slope (13b or 14b) of the other piston, and

(4) An exhaust zone E intermediate the leading slope

(13a or 14a) of the other piston and the contact line between rotors 11 and 40.

Due to its rotation in clockwise direction, piston 13 sucks a mixture of air and fuel in the case of a controlled ignition carburetor type of engine, or of air alone in the case of a fuel injection type of engine, via intake conduit 50 into the cylindrical space enclosed by wall surface 5, the fluid following the trailing slope 13b of this piston.

At the same time, the leading slope 13a of piston 13 compresses the fluid which was taken in by a previous cycle of rotor 11 in the compression space A. In the position illustrated in Figure 8a, well 33 of combustion rotor 30 is just entering into communication with combustion space C, and the already compressed fluid from that space fills the well and penetrates through channel 35 into well 34, scavenging the residual burnt gases from the entire combustion chamber constituted by wells 33 and 34 and channel 35.

The waste gases from this chamber are expelled through bypass conduit 52 into the power space P.

It is of importance that the mouth 56 of bypass conduit 52 be of such diameter that it maintains communication between the internal cavities of rotor 30 (wells 33 and 34 and channel 35) on the one hand and power space P on the other hand only for such duration as is necessary for a substantially complete removal of the burnt waste gases from the wells 33 and 34 and the channel 35 by the scavenging step (Figure 8a) and that that communication is then cut off so as to avoid unnecessary losses of fresh fluid escaping into the power and exhaust zones.

Shortly thereafter, upon further rotation of rotor 30 in counter-clockwise and rotor 11 in clockwise direction, the communication between well 34 and bypass conduit 52 is thus interrupted (Figure 8b) and further advance of piston 13 leads to further compression of the combustion fluid in the space: Zone C+channel 35+well 34. Upon further rotation, piston 13 penetrates into well 33 and the compression reaches its maximum (Figure 8c) when piston 13 is entirely in well 33. Concurrently with the interruption of communication between well 34 and bypass conduit 52, i. e. somewhat prior to the full penetration of piston 13 into well 33, piston 14 has begun to give free passage to the waste gases from zone P and conduit 52 into exhaust zone E. This is due to a suitable location of the exhaust passage 51 relative to the contact line between rotors 11 and 30.

Sparkling of spark plug 53 takes place preferably slightly before piston 13 reaches dead center position in well 33. As piston 13 passes this dead center point in well 33, piston 14 has already moved past that point through well 44.

The expanding hot gaseous combustion products push the trailing edge 13b of piston 13 and thus transmit power to the central rotor shaft 10 (Figure 8d). At the same time piston 14 has left well 44 and approaches intake opening 50, while the leading edge 13a of piston 13 begins to push the waste gases of the previous cycle out through exhaust conduit 51 (Figure 8d).

The trailing edge 13b of piston 13 is further moved clockwise under pressure from the expanding burnt gases in the space constituted by power zone P+well 33+channel 35+well 34. As the trailing edge 33b of well 33 reaches wall portion 59 intermediate bypass conduit 52 and the central chamber and cavity enclosed by wall surfaces 5 and 6, the leading edge 33a of well 33 opens communication of the latter with bypass conduit 52 thus maintaining the above defined expansion space. During the expansion of the burnt gases behind the trailing slope 13b of piston 13, the leading slope 14a of piston 14 cuts off the intake conduit 50 from the zone forward of that piston and compresses the fluid therein, while suctioning new fluid into the space behind the piston following its trailing edge 14b (Figure 8a).

Upon further rotation, piston 14 reaches the position

occupied by piston 13 in Figure 8a, and the cycle of operation described above is repeated.

As will be seen from the different figures, and preferably in Figure 1, particularly in engines of the carburetor type the angular displacement of intake 50 relative to the line of contact between rotors 40 and 11 and taken at the axis of the central rotor, is so chosen, that communication between the explosive mixture (fuel containing explosive mixture) entering through the intake port 50, on the one hand, and the exhaust zone on the other hand, by way of wells 43 and 44, of sealing rotor 40 is effectively prevented.

Furthermore, in order to avoid that the intake stroke is unnecessarily shortened as compared with the exhaust stroke, the position of the axis of sealing rotor 40 is located in a plane passing through the axis of the central rotor, which plane forms a slight angle  $\alpha$ , with the plane common to the axes of central rotor 11 and combustion rotor 30, the displacement being toward the exhaust part. Thereby the intake and the exhaust strokes are made substantially of equal length as described in my copending application Ser. No. 688,908 supra.

#### Advantages

The feature of my invention that the wells of the internal combustion rotor serve at the same time as the combustion chamber of the rotary engine, offers the following advantages:

(a) Cooling of the rotor is greatly facilitated since more space in the interior of the rotor is available for passing coolant therethrough than if separate combustion chambers would be provided apart from the wells.

(b) The cooling effect can be uniformly extended to all walls, both external and internal of the combustion rotor, since all of these walls can be provided of substantially uniform thickness.

(c) Substantially all of the hot waste gases left in the wells and the connecting channel in the interior of the combustion rotor can be effectively scavenged by fresh fluid pushing these waste gases out through the bypass conduit 52; at the same time, the fresh fluid being at a much lower temperature than the hot waste gases, acts as an additional coolant for the internal walls of the combustion rotor.

(d) The introduction of an undesirably large amount of waste gases from a preceding into the next following work cycle is avoided and the expulsion of carbon and the like residues is facilitated.

(e) The combustion which takes place in one of two wells of the combustion rotor connected by an internal channel, and in the channel itself heats the walls of the latter as well as of the aforesaid well and thereby provides a certain preheating of the next following charge of fresh gas prior to the combustion of the latter.

(f) The turbulence of the gas caused by their passage into the well-connecting channel in the combustion rotor provides for a better homogenization of the fuel containing gas mixture and accelerates the inflammation of the mixture.

The particular shape and dimensions of the channel connecting the wells in the combustion rotor in accordance with my invention are so devised as to facilitate the passage of fluid therethrough during the expansion stage of the work cycle. Thus, the channel is of a somewhat smaller cross section than the cross section of the pistons at their ridge or top surface.

Further advantages reside in the placement of the spark plug or plugs in the external wall of the casing, whereby more space is available in the interior of the combustion and in the adjacent part of the casing for providing cooling spaces for the passing of coolant therethrough, while in the previous arrangement this space had to be sacrificed for the location of the spark plugs. These additional cooling spaces are designated by 4a and 4b in Figure 2.

The aforesaid novel arrangement of the spark plugs also permits the use of smaller rolling contact bearings such as ball bearings 101 and the sealing means 102 about the shaft 31 of rotor 30 externally of the bearing 101 are of much smaller internal diameter and consequently a smaller friction-causing contact surface with the rotor shaft 31, than is the case for instance, in the arrangement of previous combustion rotors.

Also, it is easier to attach the electrical spark control system to the spark plug or plugs, and they are more easily cooled and replaceable.

While, in earlier constructions, such as those of my pending patent applications Ser. Nos. 574,833 and 688,908 supra, a separate exhaust channel for the combustion rotor had to be provided, this separate channel is made unnecessary in the system of my present invention and a single exhaust conduit for the central rotor exhaust space and the corresponding combustion rotor is sufficient.

While the invention has been explained in detail above at the hand of examples of a rotary engine of the carburetor type, i. e. which is provided with a controlled ignition system, the same invention can also easily be applied in rotary engines of the fuel injection and compression ignition or diesel type.

In this case, the spark plugs in the above described embodiments of my invention are replaced by fuel injectors which are disposed inclined relative to the plane through the combustion rotor axis so as to bring about ignition of the compressed air fuel mixture at maximum compression, i. e. at dead center position of the piston in the well of the combustion rotor.

In the same manner, this invention may also be applied to a fuel injector type engine having a controlled ignition system. In this case a fuel injector and a spark plug are arranged with each pair of wells of a combustion rotor of the type described in accordance with the invention, that fuel is first injected into the combustion chamber consisting of wells and connecting channel in the combustion rotor, and that the resulting compressed air fuel mixture is then ignited, still substantially in the range of dead center position, by means of the spark plug.

It will be understood that this invention is susceptible to modification in order to adapt it to different usages and conditions and, accordingly, it is desired to comprehend such modifications within this invention as may fall within the scope of the appended claims.

What I claim is:

1. In a rotary engine of the type described and having internal combustion rotor means with wells therein for the passage of the pistons of the central rotor of said engine, the improvement of channel means connecting every two wells in said combustion rotor means with each other, and said two wells and the channel means connecting the same constituting together one integral combustion space in said combustion rotor.

2. In a rotary engine of the type described and having an internal combustion rotor with wells therein for the passage of the pistons of the central rotor of said engine, the improvement of channel means within said combustion rotor and connecting the wells of said combustion rotor in pairs with each other, and constituting together with each pair of wells a combustion chamber in said combustion rotor.

3. In a rotary engine of the type described, the improvement comprising at least one internal combustion rotor having at least one pair of wells in the external surface of said rotor, and a channel within the interior of said rotor and connecting the two wells of said pair freely communicatingly with each other, so as to provide a continuous combustion chamber within said rotor.

4. The improvement described in claim 1, wherein said channel means pass through the central axis of the combustion rotor.

5. The improvement described in claim 3, wherein said channel is so disposed as to connect two wells located diametrically opposite each other in the external rotor surface.

6. In a rotary engine of the type described, the improvement comprising at least one internal combustion rotor having a plurality of pairs of wells in the external surface of said rotor, the two wells of each pair being diametrically disposed relative to the rotor axis, and a plurality of channels within the interior of said rotor and connecting the two wells of each pair freely communicatingly with each other, so as to provide a plurality of continuous combustion chambers within said rotor.

7. In a rotary engine of the type described and having internal combustion rotor means with wells therein for the passage of the pistons of the central rotor of said engine, the improvement, in combination, of channel means connecting every two wells in said combustion rotor with each other, said two wells and the channel means connecting the same constituting together an integral combustion chamber in said combustion rotor, and means causing the ignition of a combustible mixture in said combustion chamber and disposed in the external wall of the engine casing.

8. The improvement as described in claim 7, wherein said ignition-causing means comprise at least one electrical spark plug.

9. The improvement as described in claim 7 wherein said ignition-causing means comprise fuel injector means.

10. The improvement as described in claim 7 wherein said ignition-causing means comprise fuel injector means together with at least one electrical spark plug.

11. A rotary engine of the internal combustion type comprising, in combination, a casing, wall means in said casing enclosing an annular central chamber, and a number of cavities laterally disposed of and opening into said central chamber, a central rotor rotatably mounted in said central chamber, a plurality of pistons projecting outwardly from said central rotor and fitting into said central chamber for frictionless rotation therein, a combustion rotor rotatably mounted in one of said lateral cavities, a gate rotor rotatably mounted in another of said lateral cavities, the axes of rotation of said central rotor, said combustion rotor and said gate rotor being parallel to each other, said combustion rotor comprising two wells for the passage of said pistons therethrough, which wells are disposed diametrically opposite each other in the combustion rotor and open toward the outside thereof, and an internal channel connecting said two wells with each other, said wells and channel in said combustion rotor constituting a combustion chamber therein, exhaust conduit means in said casing opening into said central chamber, said central chamber being subdivided into an intake zone, a compression zone, a power zone and an exhaust zone during the synchronized rotation of said rotors in conjunction with rotation of said pistons through said central chamber, a bypass conduit leading from the cavity housing said combustion rotor to said central chamber through the wall of said casing so as to provide communication between a well of said combustion rotor and a space between the latter rotor and a piston of said central rotor when said piston has travelled a predetermined distance after leaving said well, means for introducing and igniting a combustible fluid mixture in said combustion chamber of said combustion rotor and comprising intake conduit means in said casing wall, gear means for causing rotation in unison of said central rotor, combustion rotor, and gate rotor, and a starting motor adapted for starting rotation of said central rotor.

12. A rotary engine of the internal combustion type comprising, in combination, a casing, wall means in said casing enclosing an annular central chamber, and a number of cavities laterally disposed of and opening into said central chamber, a central rotor rotatably mounted in said central chamber, a plurality of pistons projecting

outwardly from said central rotor and fitting into said central chamber for frictionless rotation therein, a combustion rotor rotatably mounted in one of said lateral cavities, a gate rotor rotatably mounted in another of said lateral cavities, the axes of rotation of said central rotor, said combustion rotor and said gate rotor being parallel to each other, said combustion rotor comprising two wells for the passage of said pistons therethrough, which wells are disposed diametrically opposite each other in the combustion rotor and open toward the outside thereof, and an internal channel connecting said two wells with each other, said wells and channel in said combustion rotor constituting a combustion chamber therein, exhaust conduit means in said casing opening into said central chamber, said central chamber being subdivided into an intake zone, a compression zone, a power zone and an exhaust zone during the synchronized rotation of said rotors in conjunction with rotation of said pistons through said central chamber, a bypass conduit leading from the cavity housing said combustion rotor to said central chamber through the wall of said casing so as to provide communication between a well of said combustion rotor and a space between the latter rotor and a piston of said central rotor when said piston has travelled a predetermined distance after leaving said well, means for introducing and igniting a combustible fluid mixture in said combustion chamber of said combustion rotor and comprising intake conduit means in said casing wall, and a spark plug located in the portion of the wall of said casing surrounding the peripheral inner wall enclosing said cavity of said combustion rotor, gear means for causing rotation in unison of said central rotor, combustion rotor, and gate rotor, and a starting motor adapted for starting rotation of said central rotor.

13. A rotary engine of the internal combustion type comprising, in combination, a casing, wall means in said casing enclosing an annular central chamber, and a number of cavities laterally disposed of and opening into said central chamber, a central rotor rotatably mounted in said central chamber, a plurality of pistons projecting outwardly from said central rotor and fitting into said central chamber for frictionless rotation therein, a combustion rotor rotatably mounted in one of said lateral cavities, a gate rotor rotatably mounted in another of said lateral cavities, the axes of rotation of said central rotor, said combustion rotor and said gate rotor being parallel to each other, said combustion rotor comprising two wells for the passage of said pistons therethrough, which wells are disposed diametrically opposite each other in the combustion rotor and open toward the outside thereof, and an internal channel connecting said two wells with each other, said wells and channel in said combustion rotor constituting a combustion chamber therein, exhaust conduit means in said casing opening into said central chamber, said central chamber being subdivided into an intake zone, a compression zone, a power zone and an exhaust zone during the synchronized rotation of said rotors in conjunction with rotation of said pistons through said central chamber, a bypass conduit leading from the cavity housing said combustion rotor to said central chamber through the wall of said casing so as to provide communication between a well of said combustion rotor and a space between the latter rotor and a piston of said central rotor when said piston has travelled a predetermined distance after leaving said well, means for introducing and igniting a combustible fluid mixture in said combustion chamber of said combustion rotor and comprising intake conduit means in said casing wall, and a spark plug located in the portion of the wall of said casing surrounding the peripheral inner wall enclosing said cavity of said combustion rotor, in the zone of said inner wall intermediate the limits defined, on the one hand by the opening of said bypass channel into said combustion rotor cavity and, on the other hand, by the leading edge of one of

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the wells of said combustion rotor in that position of the latter in which the other well connected to the former well by said internal channel is filled substantially completely by a piston of said central rotor; gear means for causing rotation in unison of said central rotor, combustion rotor, and gate rotor, and a starting motor adapted for starting rotation of said central rotor.

14. A rotary engine of the internal combustion type comprising, in combination, a casing, wall means in said casing enclosing an annular central chamber, and a number of cavities laterally disposed of and opening into said central chamber, a central rotor rotatably mounted in said central chamber, a plurality of pistons projecting outwardly from said central rotor and fitting into said central chamber for frictionless rotation therein, a combustion rotor rotatably mounted in one of said lateral cavities, a gate rotor rotatably mounted in another of said lateral cavities, the axes of rotation of said central rotor, said combustion rotor and said gate rotor being parallel to each other, said combustion rotor comprising two wells for the passage of said pistons therethrough, which wells are disposed diametrically opposite each other in the combustion rotor and open toward the outside thereof, and an internal channel connecting said two wells with each other, said wells and channel in said combustion rotor constituting a combustion chamber therein, exhaust conduit means in said casing opening into said central chamber, said central chamber being subdivided into an intake zone, a compression zone, a power zone and an exhaust zone during the synchronized rotation of said rotors in conjunction with rotation of said pistons through said central chamber, a bypass conduit leading from the cavity housing said combustion rotor to said central chamber through the wall of said casing so as to provide communication between a well of said combustion rotor and a space between the latter rotor and a piston of said central rotor when said piston has travelled a predetermined distance after leaving said well, means for introducing and igniting a combustible fluid mixture in said combustion chamber of said combustion rotor and comprising intake conduit means in said casing wall, for the admission of a comburent, and fuel injection means, gear means for causing rotation in unison of said central rotor, combustion rotor, and gate rotor, and a starting motor adapted for starting rotation of said central rotor.

15. A rotary engine of the internal combustion type comprising, in combination, a casing, wall means in said casing enclosing an annular central chamber, and a number of cavities laterally disposed of and opening into said central chamber, a central rotor rotatably mounted

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in said central chamber, a plurality of pistons projecting outwardly from said central rotor and fitting into said central chamber for frictionless rotation therein, at least one combustion rotor rotatably mounted in one of said lateral cavities, at least one gate rotor rotatably mounted in another of said lateral cavities, the axes of rotation of said central rotor, said combustion rotor and said gate rotor being parallel to each other, said combustion rotor comprising at least one pair of wells for the passage of said pistons therethrough, which wells are disposed diametrically opposite each other in the combustion rotor and open toward the outside thereof, and an internal channel connecting the two wells of said pair with each other, said wells and channel in said combustion rotor constituting a combustion chamber therein, intake and exhaust conduits in said casing opening into said central chamber, at least one bypass conduit, said bypass conduit leading through the casing wall from the cavity housing said combustion rotor to said central chamber, and opening thereinto so as to provide communication between a well of said combustion rotor and a space between the latter rotor and a piston of said central rotor when said piston has travelled a predetermined distance after leaving said well, means for igniting a combustible fluid mixture in said combustion chamber of said combustion rotor, gear means for causing rotation in unison of said central rotor, combustion rotor, and gate rotor, and a starting motor adapted for starting rotation of said central rotor.

16. A rotary engine as described in claim 11, wherein said bypass channel opens into said cavity housing said combustion rotor at such position relative to the intersection of said cavity with said central chamber and to said exhaust part in the wall of the latter, that free communication is established between said compression zone of said central chamber and said exhaust part via the two wells of said combustion rotor, the internal channel connecting said pair of wells, said bypass channel and the exhaust zone of said central chamber for a short time so as to permit scavenging of the several aforesaid spaces by means of fresh gaseous fluid compressed in front of the leading slope of a piston of said central rotor approaching the intersection of said central chamber with said combustion rotor cavity, while avoiding substantial losses of fresh gaseous fluid by cutting off the above-mentioned free communication prior to a substantial amount of said fresh fluid penetrating through said bypass channel into said power zone.

No references cited.