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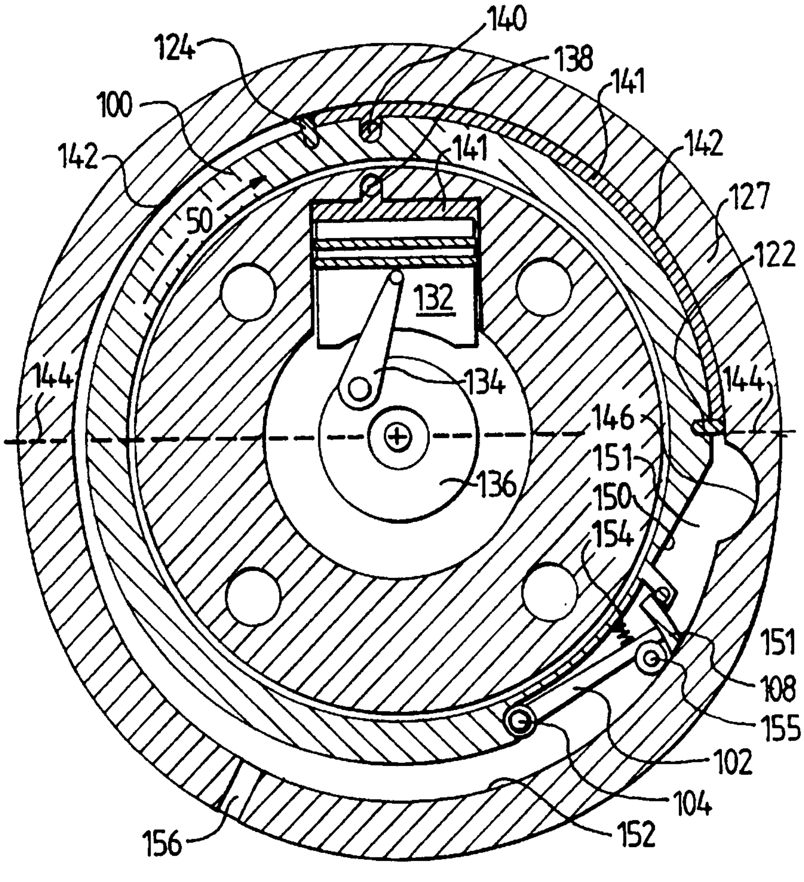
(54) Title: ROTARY ENGINE

(57) Abstract

A rotary type internal combustion engine having a stationary stator housing (127) and a rotor (100) which is rotatably mounted within the stator housing (127). The rotor has a thrust face (108) which is exposed to combusted gases within the engine. The thrust face (108) has a variable surface area. The stator has a profiled inner surface (152) or a contoured end cap which varies the surface area of the thrust face (108) exposed to combusting gases and thus provides the engine with a required torque characteristic. The engine further comprises a compressor assembly (132, 134, 136) located within the rotor (100) for supplying a compressed charge to a combustion chamber which includes the thrust face (108).



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ROTARY ENGINE

TECHNICAL FIELD

This invention relates to engines and/or compressors and has been devised particularly, but not soley, for rotary type internal combustion engines.

BACKGROUND ART

In known internal combustion engines such as those having a piston which reciprocates in a cylinder, the torque produced is dependent upon the combustion of a combustible mixture of gases supplied to the combustion chamber formed between the cylinder and piston. The force on the upper surface of the piston which provides the engine torque rapidly reduces as the volume of the combustion chamber expands with movement of the piston away from the end of the cylinder. Also, a large component of the force on the piston at ignition acts through the centre of the crankshaft. Only a small component of the force on the piston acts in a direction which is tangential to the locus of rotation of the crank shaft. Thus the torque produced by each stroke of the piston diminishes very quickly, usually within the first 30 degrees of the engine cycle after the beginning of the engine power stroke. This results in low average torque output and corresponding poor mechanical efficiency.

Known rotary type internal combustion engines have a rotating member, or rotor which is housed within a stationary stator housing. The combustion chamber is formed between parts of the outer peripheral surface of the rotor of the engine and the inner circumferential surface of the stator. A primary advantage of rotary engines is that the connecting rod of the reciprocating engine is not required so the gas pressure applied to the rotor is directly transmitted to the output shaft to generate torque.

One form of known rotary engine is the Maillard compressor or engine. Another less well known form of rotary engine is the Mallory engine. Both these engines have rotors which rotate eccentrically in the stator housing. The Mallory engine has the rotor divided into chambers by a number of vanes. The rotor rotates eccentrically within the stator housing while the vanes move inwardly and outwardly to and from the rotor body to maintain contact with the inner surface of the stator. In this way the available thrust receiving surface of the rotor vanes exposed to the combusting gases increase during the combustion cycle. This increases torque through the combustion cycle as the thrust face area on which the combusting gases exert force increases with rotation of the rotor.

However, the forces exerted on the rotor of the Maillard and Mallory engines are not tangential to the rotor due to the eccentric mounting of the rotor relative to the stator. Furthermore, these engines both make use of the eccentric rotor configuration to compress the inlet gasses and thererfore complete the four cycles of gasses inlet, compression, combustion/expansion and exhaust in every 360 degree rotation of the rotor. Both these factors limit torque and thus power output. Also, the complexity and large number of moving parts of the Mallory engine make it undesirable for commercial production and difficult to maintain.

It is an object of the present invention to provide internal combustion engine which will at least go some way toward overcoming the foregoing disadvantages, or which will at least provide the public with a useful choice.

DISCLOSURE OF INVENTION

In one aspect the invention consists in an internal combustion engine, comprising;

a stator having ignition means for igniting combustible gases, external gases communication means for supply of gases and the removal of combusted gases from said engine, and an inner surface,

a rotor rotatably mounted in said stator having an outer peripheral surface,

a combustion chamber comprising parts of said surfaces in which combustible gases are ignited and combust during a combustion cycle to cause said rotor to rotate relative to said stator,

a first thrust face and a second thrust face provided on said rotor, said first and second thrust faces comprising walls of said combustion chamber, and

an expansion path guide means for exposing a required area of said first thrust face to combusting gases during said combustion cycle to provide forces of different magnitudes on each said thrust face to provide a required engine torque characteristic.

In a further aspect the invention consists in a method of operating an internal combustion engine, said method comprising the steps of;

supplying inlet gases to a combustionchamber of said engine,

igniting said gases,

varying the area of one wall of said combustion chamber exposed to said gases, and maintaining the area of the other walls of said combustion chamber substantially constant so as to provide a required engine torque characteristic.

In a further aspect the invention consists in a method of operating an internal combustion engine, said method comprising the steps of;

supplying inlet gases to a first chamber of said engine during part of a combustion cycle of said engine,

compressing said inlet gases in said first chamber for supply to said engine,

transferring said compressed gases to a combustion chamber of said engine, and

combusting said gases to effect mechanical movement.

In a further aspect the invention consists in a stationary housing for housing an engine or compressor, said housing comprising a central casing having an inner circumferential surface, a first part of said inner surface being circular and concentric with a surface of said rotor, and a second part of said inner surface being profiled so that an area of said thrust face of said rotor exposed to working gases in said engine is progressively increased or decreased during at least part of the operating cycle of said engine or compressor.

In a further aspect the invention consists in a rotor for an engine or compressor, said rotor comprising a body, a support means for mounting said body relative to a stationary housing of said engine or compressor so as to allow relative rotational movement between said body and said housing, said body having a thrust face and an arm member pivotally attached to a peripheral portion of said body and moveable relative to said body so that movement of said arm member relative to said body increases or decreases an area of said thrust face exposed to working gases during at least part of the operating cycle of said engine or compressor.

The invention consists in the foregoing and also envisages constructions of which the following gives examples.

BRIEF DESCRIPTION OF DRAWINGS

Preferred forms of the present invention will now be described with reference to the accompanying drawings in which;

Figure 1 is a diagrammatic side elevation of a rotor for an internal combustion engine;

Figure 2 is a diagrammatic elevation in cross section of an internal combustion engine including the rotor of figure 1 and a piston compression means at the inlet stage of the engine operating cycle;

Figure 3 is a diagrammatic elevation in cross section of the engine shown in figure 2 at the combustion stage of the engine operating cycle;

Figure 4 is a diagrammatic elevation in cross section of the engine shown in figure 3 at the end of the combustion stage of the engine operating cycle;

Figure 5 is a graph of torque (in foot pounds) and combustion chamber pressure (in pounds per square inch) plotted against rotor rotation in degrees for an engine in accordance with the present invention;

Figures 6, 7 and 8 are diagrammatic end elevations in cross-section of alternative forms of engine in accordance with the present invention;

Figure 9 is a diagrammatic elevation in cross section in a plane parallel to the axis of rotation of the rotor of an engine having a rotor which is similar to that of figure 1 and having a trochoidal rotor compression means at an inlet stage of the engine operating cycle;

Figure 10 is a diagrammatic end elevation in cross section of the engine of figure 5 in which some detail has been omitted for clarity; and

Figure 11 is a diagram of a cycle of operation of an engine in accordance with the present invention.

BEST MODES OF CARRYING OUT THE INVENTION

Referring to figure 1 a rotor 100 of a rotary engine is shown having an outer peripheral surface 101. A trailing arm 102 is pivotally attached to the rotor by a pin 104 so that the arm is free to rotate about pin 104, and may move into or out of recess 106 provided in the outer peripheral surface 101 of rotor 100. The trailing arm 102 has a first thrust face 108 and a cam roller 110. Edge 105 of recess 106 provides a shielding means which shields the thrust face 108 from the combusting gases during the combustion cycle. The cam roller provides a guide for movement of the arm 102 relative to edge 105 and recess 106 and is configured to either follow an inner circumferential surface of the stator as will be described further below, or to follow a machined groove having a desired contour in an inner surface of a front and/or rear end cap of the engine. Thrust face 108 has a face seal 112 which in use forms a substantially gas-tight seal with an inner circumferential surface of the stator.

The outer peripheral surface 101 of the rotor has a further recess 114 which in use forms part of the combustion or working chamber of the engine as will be described further below. Seals 116, 118, 120 and 122 are provided between recess 114 and the engine end-cap on each side of the rotor to substantially prevent gases escaping from the combustion chamber between the rotor and the engine end-cap.

A further inlet gas seal 124 is provided to effect a substantially gas-tight seal between the inner circumferential surface of the stator and surface 101 of the rotor at the location of seal 124. Wall 125 of seal 124 provides a second thrust face. A seal 126 is provided between seals 122 and 124 and between the rotor and the engine end-cap. A similar seal to seal 126 is provided on the other side of the rotor.

Referring to figure 2 the rotor 100 of figure 14 is shown in cross-section mounted within and relative to a stator housing 127, also in cross-section, of an engine in accordance with the present invention. The rotor is preferably mounted on ball bearing races. Within the rotor 100 is a stationary housing 128 which contains a cylinder 130 within which a piston 132 is provided. The piston 132 is connected by a connecting rod 134 to a rotating crankshaft 136. Another part of cylinder 130 has a gases outlet port 138. A corresponding gases inlet port 140 is provided in the stator. The stator has an inner circumferential surface 142 which on the upper side of dashed line 144 is circular, and on the lower side of 144 follows a selected profile, for example an elliptical profile dependent upon the desired torque requirements of the engine. The upper circular part of the inner circumferential surface 142 is concentric with the outer peripheral surface of the rotor and preferably remains concentric for the upper 180 degrees of rotation shown above dashed line 144 in figure 2.

The operation of the engine is as follows:

In the position shown in figure 2, a mixture of combustible gases has been supplied to cylinder 130 through an inlet port in the front end cap of the engine. Rotation of crankshaft 136 which is connected to the rotor output shaft has moved the piston 132 upwardly toward the top of the cylinder so as to compress the gases therein. The rotor has rotated in a clockwise direction shown by arrow 50 to a position in which port 138 is open to inlet port 140 of the stator via a passsgeway provided in the engine front end-cap, so that the compressed gases (represented by shading 141 in figure 2) have entered port 140 of the stator and are located between seals 124 and 122. Therefore, at this point in the operating cycle of the engine, the compressed combustible mixture of gases is provided between seals 122 and 124, part of the rotor outer peripheral surface, part of the stator inner circumferential surface, and the engine end-caps.

Turning to figure 3, the rotor has rotated to a position whereby seal 122 has gone past a combustion chamber recess or cavity 146 and past the point on the inner surface of the stator at which the inner surface ceases to be circular and concentric with the rotor. The recess 146 in the inner surface of the stator provides a wall of a combustion chamber formed between the rotor and stator and a spark plug 148 is provided therein. As seal 122 passes the entrance to recess 146, the compressed combustible gases pass seal 122 and enter the recess 146 and the corresponding recess 150 in the rotor up to sealed thrust surface 108 of the trailing arm. The combustible gases are now located in a combustion chamber formed between thrust surface 108, rear seal 124, and the surfaces of the rotor and stator there between including the recess 150 in the rotor and 146 in the stator. The area of these recesses is shown by shading 151 in figure 2. The compressed gasses in the combustion chamber between the rotor and stator are shown At the time, or shortly after the compressed combustible gases pass seal 122, they are ignited by spark plug 148. The burning gasses in the combustion chamber are shown by shading 153 in figure 3. As the combustible gases ignite and burn, forces are exerted on the surfaces of the rotor and stator and end caps of the engine between the first thrust face 108 and second thrust face 125 of seal 124. The geometry of the combustion chamber is designed so that the much greater surface area of the thrust face as compared with face 125 results in a greater force being applied to the thrust face than the face 125 for any given gas pressure in the combustion chamber. This causes the rotor to rotate in a clockwise direction as shown by arrow 50. As the rotor rotates, the inner surface profile 152 of the stator is no longer circular, but is for example elliptical. The trailing arm 102 moves outwards relative to the rotor, being biassed against the stator inner circumferential surface by spring 154 to expose an increasingly larger proportion of thrust face 108 to the forces exerted by the combusting gases. The path followed by the trailing arm may be controlled soley by the profile or contour of the inner surface of the stator below lines 144, or by machining a groove following the stator surface profile in one or both end-caps of the engine and providing a cam follower 155 on the trailing arm which follows the machined groove. As the torque produced by the engine is dependent upon the area of the thrust face exposed to the combusting gases in the combustion chamber less the constant area of face 125 of seal 124 exposed to the combusting gases, the profile 152 of the inner circumferential surface of the stator can be selected so that a desired engine torque characteristic can be achieved. For example, a substantially constant, or increasing, torque can be produced throughout the combustion cycle.

Referring to figure 4, the rotor is shown in a position in which the combustion cycle has substantially finished, and the combusted gases are allowed to exit the engine through the exhaust port 156. The engine scavenges the exhaust gases by means of the thrust face 108 which effectively sweeps the gases out the exhaust port during the next combustion cycle. Seal 124 prevents the exhaust gases from entering that area of the rotor between seals 122 and 124, so that the exhaust gases do not interfere with the succeeding combustion cycle. It will be seen that the piston 132, connecting rod 134 and crankshaft 136 assembly provides compressed gases to the engine by operating as a two stroke compressor and being timed so that the piston 132 compresses the combustible gases ready for transfer from port 138 to inlet port 140 at the time of maximum compression. Furthermore, it will be seen that the piston, connecting rod and crankshaft assembly is not necessary for operation of the engine. All that is necessary is a supply of compressed gases to inlet port 140. Also, the compressed gasses do not need to comprise a combustible mixture, as fuel injection methods could be used to inject fuel directly into the combustion through the stator housing.

Figure 5 graphically illustrates the torque output of an engine according to the present invention. The horizontal axis is rotor rotation in degrees relative to the stator. The left-hand axis is engine output torque in foot-pounds (ft.lbs) and the right-hand axis is combustion chamber pressure in pounds per square inch (psi). Locus 160 is the combustion chamber pressure vs rotor rotation for a 45mm wide rotor supplied with gasses from a compressor having a 125cc displacement. Locus 160 is predictable and achieveable by design of the contour of inner circumferential surface 152. The initial combustion chamber pressure of 555 psi at 10 degrees is derived from assuming an engine compression ratio of 9:1 and a 14:1 air/fuel ratio. Locus 160 also represents the combustion chamber pressure for an engine having a 60 mm wide rotor and a stator inner surface profile which is the same as that of the engine with the 45 mm wide rotor. The pressure drops suddenly from 60 psi to zero at 90 degrees as this is where the exhaust port is located in this example.

From locus 160 the engine torque may be calculated. Engine torque is combustion chamber pressure, multiplied by thrust face area exposed to the combusting gasses less the area of seal 124 exposed to combusting gasses, multiplied by the distance of pivot 104 from the centre of rotation of the rotor. Assuming twenty eight percent thermal efficiency, locus 162, which represents torque produced by the engine having the 45 mm wide rotor engine, can be plotted.

Referring to locus 162 it can be seen that the torque increases for the first 40 degrees, then remains constant for 30 degrees before decreasing steadily until exhaust. Clearly the stator inner surface profile can be designed to provide any torque characteristic that the user requires.

Locus 164 represents torque for the engine having the 60 mm wide rotor and compressor of 125 cc swept volume. Because of the greater rotor surface area the torque increases above that of locus 162. The torque decreases after 60 degrees, but due to the inner surface profile, increases again at 80 degrees before falling to zero at exhaust. If the exhaust port is instead provided at 100 degrees, and the stator inner surface correspondingly modified, then the torque locuses 162 and 164 could be extended to 100 degrees as shown by dashed lines 166 and 168.

Many different compressor configurations are possible. Referring to figure 6, an engine similar to that described above is shown in end elevation in cross-section. The difference between the engine of figure 6 and the engine of the preceding figures is that the engine of figure 6 has a stationary crankshaft 136. Front end-cap 190 has a spline receiving portion 192 for receiving splined end 194 of the crankshaft. Rear end-cap 196 has bearings 198 which support rotor output shaft 200 and the output shaft has further bearings 202 which support the other end of the crankshaft. Thus the piston rotates with the rotor and compresses inlet gasses from a carburettor for example which enter the engine through port 204 using a two-stroke action. The compressed gasses are provided directly to the engine through port 206. A significant advantage of this embodiment of the invention is the ability to alter the engine torque characteristics by altering the rotational position of the front end-cap or a part of the front end-cap connected to splined portion 192 relative to the stator. This changes the position of the crankshaft and thus alters the position of top dead center of the piston so that the pressure of the compressed gasses supplied to the combustion chamber can be varied.

Figure 7 shows a variation of the engine of the present invention in which th cranshaft is able to rotate and the cylinder is located within a stationary housing 208 bolted for example to front end-cap 190 at 210. The front end-cap has bearings 212 which support the crankshaft and an inlet port 204. The rotor has a splined portion 214 for receiving splined portion 216 of the crankshaft. The compressor operates in a two stroke manner to compress gasses. Port 218 is aligned with passageway 220 in the end-cap and when passageway 220 is aligned with passageway 222 in the rotor, compressed gasses are supplied to the engine.

Referring to figure 8 a further form of engine is shown in exploded end elevation in cross-section. The construction previously described is shown including a thrust spacer 226 and a rotor internal spline 228. The compressor unit is located externally of the engine and is driven by the interconnection of splined shaft 230 with internal spline 228. Bearing caps 232 are provided for mounting the compressor crankshaft relative to stationary housing 234. The compressor has an outlet port 236 for supplying compressed gases to the engine. A rotary valve assembly 238 is also provided, driven by belt driven pulleys 240, for allowing the piston 132 to operate as a four stroke compressor. Poppet valves could alternatively be used, but with less efficiency. The higher compression ratios achievable through four stroke compressor operation enable higher engine torque to be achieved, and also allow the engine to use diesel as a fuel. Under diesel operation the output power of the engine is at least three times that under petrol operation. Diesel operation requires the direct injection of fuel to the engine through the stator housing.

An alternative to the piston, connecting rod and crankshaft assembly is shown in figure 9 in which a trochoidal rotor is located within rotor 100 for the purpose of compressing the combustible gases.

The basic structure of the engine shown in figure 9 is substantially the same as the "single displacement" engines described above, however two trailing arms 102 and two rotor recesses 150 are provided to provide a "twin displacement" engine. The trochoidal rotor 180 of the engine shown in figure 9 operates in a similar way to the Maillard type engine to compress the combustible gases for supply to the engine. An outlet port 138 is provided for the supply of combustible gases to each of the combustible gas containing spaces between the rotor and stator. An inlet port 139 is provided for supply of gasses to the trochoidal rotor assembly. The rotor 180 has three seals 182 to provide substantially gas-tight seals between trochoidal rotor 180 and the output rotor 100. Trochoidal rotor 180 also has three substantially gas-tight seals 184 on each side thereof to provide a seal between the trochoidal rotor and each of the engine end-caps.

Referring to figure 10, the engine of figure 9 having a trochoidal rotor for compressing the combustible gases is shown in end elevation and in cross-section. The inner trochoidal rotor 180 is mounted on a shaft (not shown) which exits the engine through aperture 188 in front end cap 190. The rotor 100 is connected to output shaft 192 which exits the engine through aperture 194 in the rear engine end-cap 196. The compressed combustible gases outlet port 138 is shown in alignment with gases supply pathway 198 in the front end-cap 190. The gases pathway 200 in the stator 142 is shown together with the lower stator gases pathway 202 which comprises a greater area than the upper gases pathway 200.

The advantages of the present invention may be seen by comparing it with a four stroke reciprocating engine. Figure 11 is a diagram of operation of the engine of figures 2, 3 and 4. Line 250 represents Top Dead Centre (TDC) of the engine, being the time at which ignition occurs. The engine inlet port 140 (figure 2) closes approximately 110 degrees before TDC at line 252. Assuming a 90 degree combustion angle, then the exhaust port opens at 90 degrees after TDC at line 254. As the inlet port closes at 110 degrees before TDC, inlet gases begin to be supplied to the compressor at this time and may be continued to be supplied to the compressor until 70 degrees after TDC at line 256. The inlet gases in the compressor can then undergo compression for 180 degrees up to line 252. Therefore, before and during combustion of the engine, inlet gases have entered the compressor and are being compressed by the end of the combustion cycle. The engine gases inlet typically opens at 220 degrees before TDC at line 258, so that compressed gases are being supplied to the engine before the engine inlet port 140 (figure2) closes at line 252. Thus the engine effectively performs the four cycles of inlet, compression, combustion and exhaust in less than 360 degrees whereas a four stroke reciprocating engine, or a Maillard engine require 720 degrees to complete these functions.

Some possible engine configurations are listed below:

1. Two horizontally opposed reciprocating compressor pistons working in phase and coupled to a "single displacement" rotor. This configuration can provide a maximum 180 degrees duration of torque.

2. Two groups of two horizontally opposed reciprocating compressor pistons, each group being coupled to a single "twin displacement" rotor. The compressor pistons are configured so as to deliver compressed gases to the engine every 90 degrees and the rotors are mounted at 90 degrees to each other, so that the engine of this configuration fires every 90 degrees and provides at least 360 degrees duration of torque.

3. A hypotrochoid type compressor coupled to a single "twin displacement" rotor. This fires every 180 degrees and can provide a maximum of 180 degrees of torque.

4. Two of the configurations of 3. above mounted at 90 degrees to each other. This configuration provides a minimum of 360 degrees of torque and provides double the torque of an engine of configuration 3. above.

5. Two of the configurations of 3. above mounted in phase with each other. This provides a maximum of 360 degrees of torque.

It can be seen that the engine fundamentally comprises a compressor, a rotor and a stator housing. The rotor is fitted with side seals and face seals, and has a trailing edge thrust seal that follows the contour of the stator inner circumferential surface.

The compressor provides the advantages that the size of the compressor can be selected to determine the compression ratio and the engine torque. The rotor has the advantages that it rotates concentrically with a major part of the stator housing and all forces on the rotor are radial. The stator housing provides, by profile, torque characteristics and by design the opportunity to be; water cooled, air cooled or oil cooled.

The inner circumferential surface of the stator may be aluminium, spheroidal graphite iron or ceramic coated for example to attempt to achieve adiabatic operation.

The engine end-caps or side plates allow mounting of an air compressor and provide a means to mount to a gearbox-transmission assembly.

Possible fuel types for use with the engine include; petrol, methanol, diesel, augas, biogas, hydrogen, or any other gaseous fuel. Also, the fuel may be direct injected into the into the combustion chamber through the stator housing, or provided with the inlet gasses by means of a carburettor.

A number of different engine configurations are possible. By changing the air compressor but using the same outer stator case the engine may be petrol or diesel.

The engine performance is predictable by design. Torque is a function of force at a fixed radius multiplied by the thrust face area presented by design. Torque commences at 5 degrees and is maximum at 40 degrees of rotation. Due to at least 30 degrees of continuous torque being attainable, in the "single displacement" engine continuous torque is achieved at 12 RPM and in the "twin displacement" at 6 RPM. In particular, it will be seen that at least with the "single displacement" engine, it is possible to achieve 360° duration of exhaust, 180° duration of inlet gas and compression, up to 180° transfer of inlet gas, 180° of combustion and 180° of torque by design.

In its simplist form (trochoidal rotor compressor) the engine has only three moving parts. With the piston air compressor it has five moving parts.

Some examples of the applications and uses of the engine are as follows:
Automotive, marine, aeronautical,industrial.

Industrial uses include the following:

Air compressor,
Power generation, set portable generators, hybrid electric cars,
Agricultural, tractors, cultivators, water reticulation, excavators,
Lawnmowers, silvicultural, sprayers,
Military
Horticultural
Forestry, log skidders, crawler tractors,
Skyline rigs, carriages, sawmills, chainsaws,
Recreational, snowmobiles, portable gensets,
Trains, locomotives,
Earth moving machinery,
As a hydraulic or water pump/motor,
As a steam engine,
As an air compressor.

It will be seen that the trailing arm 102 (figure 1) does not need to trail pivot 104 and could lead the pivot and it may be desirable to contour the thrust face, in a curve for example, to improve efficiency. Also, the arm could be used to shield or cover and progressively uncover a thrust face provided on the rotor to achieve the required change in surface area. That is, the same variable thrust face area effect could be achieved with the inner circumferential surface of the stator being completely concentric with the outer peripheral surface of the rotor.

The present invention provides an engine or compressor which is capable of a desired and controlled torque output which is many times the available torque output from presently known internal combustion engines of a similar size.

It will be seen from the foregoing that the present invention provides an engine which prolongs the torque produced by the engine over the engine power stroke so to provide an engine which provides more power for its size than known internal combustion engines.

CLAIMS

1. An internal combustion engine, comprising;

a stator having ignition means for igniting combustible gases, external gases communication means for supply of gases and the removal of combusted gases from said engine, and an inner surface,

a rotor rotatably mounted in said stator having an outer peripheral surface,

a combustion chamber comprising parts of said surfaces in which combustible gases are ignited and combust during a combustion cycle to cause said rotor to rotate relative to said stator,

a first thrust face and a second thrust face provided on said rotor, said first and second thrust faces comprising walls of said combustion chamber, and

an expansion path guide means for exposing a required area of said first thrust face to combusting gases during said combustion cycle to provide forces of different magnitudes on each said thrust face to provide a required engine torque characteristic.

2. An engine as claimed in claim 1 wherein the area of said second thrust face exposed to said combusting gases is substantially constant during said combustion cycle.

3. An engine as claimed in claim 1 or claim 2 wherein a shielding means is provided to shield a remaining part of said first thrust face from said combusting gases.

4. An engine as claimed in any one of the preceding claims wherein said required area of said first thrust face is exposed by relative movement between said first thrust face and said shielding means.

5. An engine as claimed in any one of the preceding claims wherein said first thrust face comprises a part of an arm which is pivotly attached to said rotor.

6. An engine as claimed in any one of the preceding claims wherein an edge of each of said thrust faces is biased against said inner surface and is in substantial sealing contact therewith.

7. An engine as claimed in any one of the preceding claims wherein said expansion path guide means comprise a part of said inner surface which is spaced away from said outer peripheral surface.

8. An engine as claimed in any one of claims 1 to 6 wherein said expansion path guide means comprise a contoured slot in an internal surface of an end cap of said engine.

9. An engine as claimed in claim 8 wherein said arm has a bearing surface which is located within said slot so that said movement of said arm relative to said rotor is guided by said slot.

10. An engine as claimed in any one of the preceding claims wherein a recess is provided in said rotor to receive said first thrust face, a wall of said recess providing said shielding means.

11. An engine as claimed in any one of the preceding claims wherein a first seal is provided on said rotor to provide a substantially gas-tight seal between said rotor and said stator, said first seal being located close to said first thrust face, on the side of said thrust face so as to trail said thrust face when said rotor is rotating.

12. An engine as claimed in claim 11 wherein a second seal is provided on said rotor to provide a substantially gas-tight seal between said rotor and said stator, said second seal being provided on the side of the rotor which trails said first thrust face when said rotor is rotating, and said second seal being positioned further from said first thrust face than said first seal.

13. An engine as claimed in claim 11 or claim 12 wherein said external gases communication means comprises an inlet port for supplying compressed gases to said engine, said inlet port being located to supply said gases between said first and said second seals.

14. An engine as claimed in claim 12 or claim 13 wherein a part of said second seal comprises said second thrust face.

15. An engine as claimed in any one of the preceding claims wherein gases compression means are provided to compress gases for delivery to said engine.

16. An engine as claimed in claim 15 wherein said gases compression means comprise an assembly within said rotor, said assembly having a cylinder, a piston being located within said cylinder, said piston being reciprocatable within said cylinder so as to compress gases supplied to said cylinder.

17. An engine as claimed in claim 15 wherein said gases compression means comprise an assembly located within said rotor, said assembly comprising a further rotor for compression of combustible gases supplied to said engine.

18. An internal combustion engine substantially as herein described with reference to and as illustrated by the accompanying drawings.

19. A method of operating an internal combustion engine, said method comprising the steps of;

supplying inlet gases to a combustionchamber of said engine,

igniting said gases,

varying the area of one wall of said combustion chamber exposed to said gases, and

maintaining the area of the other walls of said combustion chamber substantially constant so as to provide a required engine torque characteristic.

20. A method of operating an internal combustion engine, said method comprising the steps of;

supplying inlet gases to a first chamber of said engine during part of a combustion cycle of said engine,

compressing said inlet gases in said first chamber for supply to said engine,

transferring said compressed gases to a combustion chamber of said engine, and

combusting said gases to effect mechanical movement.

21. A method as claimed in claim 20 including the step of compressing said inlet gases in said first chamber during part of said combustion cycle.

22. A method as claimed in claim 20 or claim 21 wherein said steps of supplying inlet gases to said first chamber, compressing said inlet gases, transferring said compressed gases and combusting said gases all occur within three hundred and sixty degrees of engine operation.

23. A method as claimed in any one of claims 20 to 22 wherein said step of combusting said gases can continue for up to 180 degrees of engine operation.

24. A method as claimed in any one of claims 20 to 23 wherein said step of combusting said gases continues for at least 90 degrees of engine operation.

25. A method as claimed in any one of claims 20 to 24 wherein said step of supplying inlet gases to said first chamber continues for at least 180 degrees of engine operation.

26. A method as claimed in any one of claims 20 to 25 wherein said step of compressing said inlet gases continues for at least 180 degrees of engine operation.

27. A method of operating an engine substantially as herein described with reference to and as illustrated by the accompanying drawings.

28. A stationary housing for housing an engine or compressor, said housing comprising a central casing having an inner circumferential surface, a first part of said inner surface being circular and concentric with a surface of said rotor, and a second part of said inner surface being profiled so that an area of said thrust face of said rotor exposed to working gases in said engine is progressively increased or decreased during at least part of the operating cycle of said engine or compressor.

29. A housing as claimed in claim 28 wherein external gases communication means are provided for allowing gases to enter and exit said housing.

30. A housing as claimed in claim 28 or claim 29 wherein said central casing includes cooling passageways for carrying cooling fluid for cooling said engine or compressor.

31. A housing as claimed in any one of claims 28 to 30 including at least one end cap attached to said central casing, said end cap having rotor support means for supporting a shaft of said rotor.

32. A stationary housing substantially as herein described with reference to, and as illustrated by, the accompanying drawings.

33. A rotor for an engine or compressor, said rotor comprising a body, a support means for mounting said body relative to a stationary housing of said engine or compressor so as to allow relative rotational movement between said body and said housing, said body having a thrust face and an arm member pivotally attached to a peripheral portion of said body and moveable relative to said body so that movement of said arm member relative to said body increases or decreases an area of said thrust face exposed to working gases during at least part of the operating cycle of said engine or compressor.

34. A rotor for an engine or compressor substantially as herein described with reference to, and as illustrated by, the accompanying drawings.

35. Any novel feature or combination of features described herein.

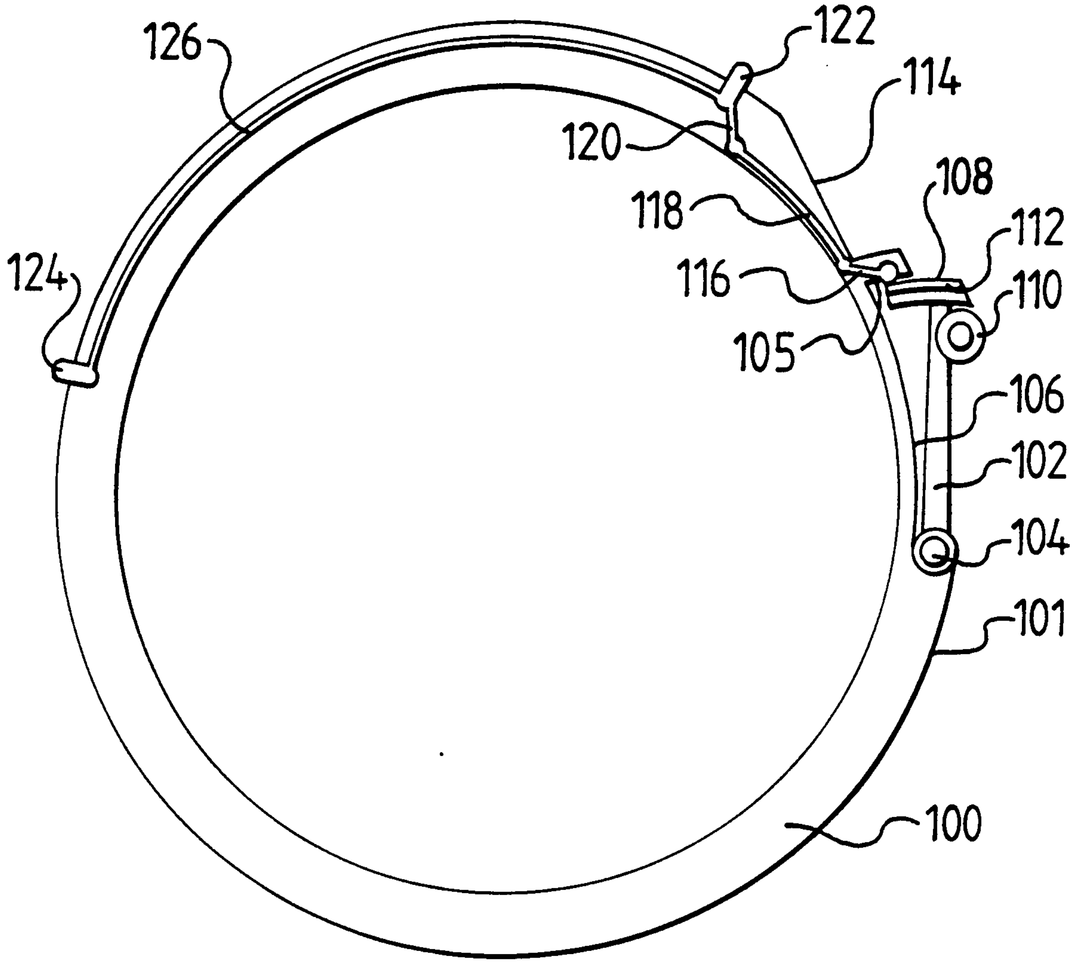

FIG.1

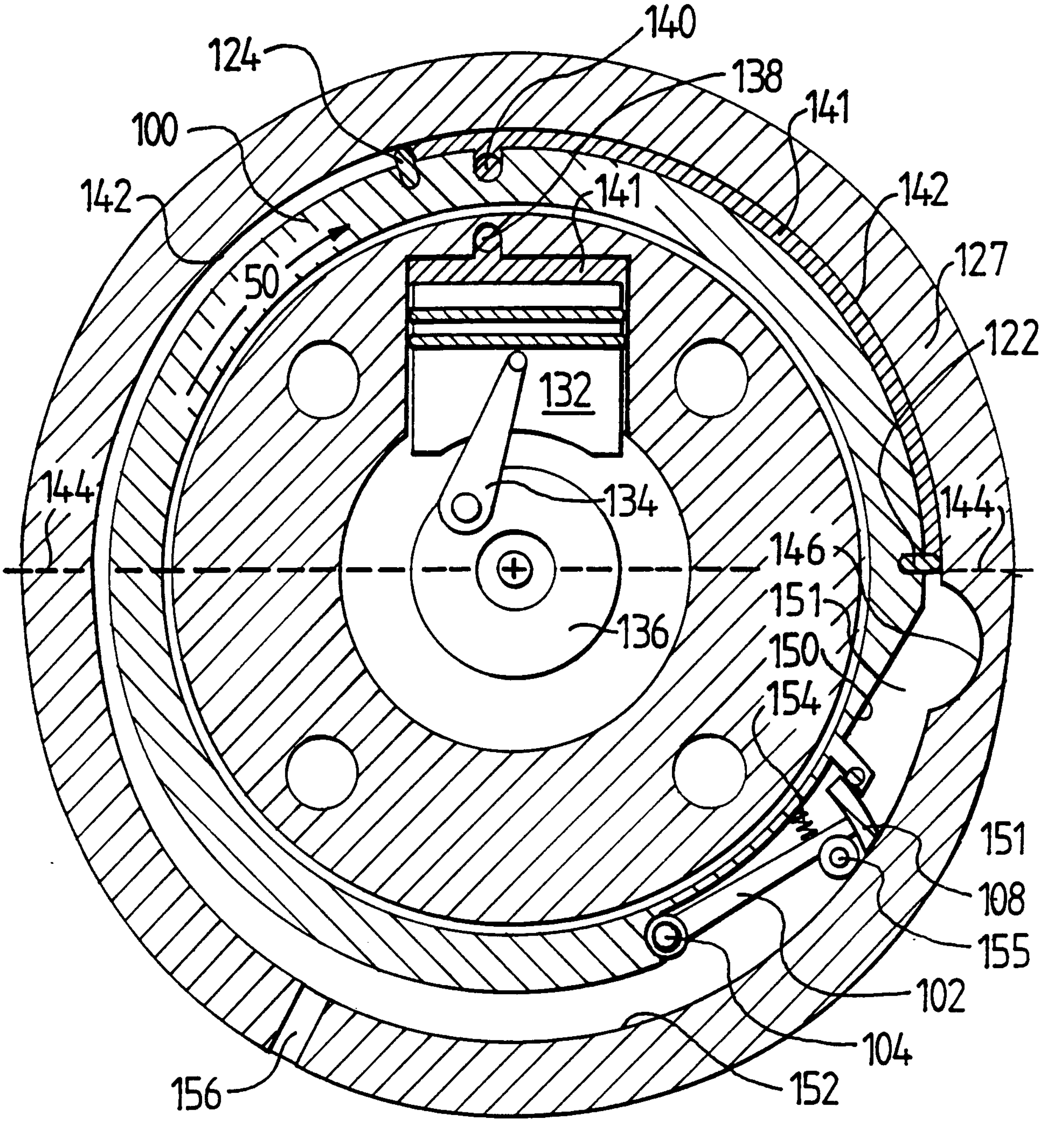
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FIG. 2

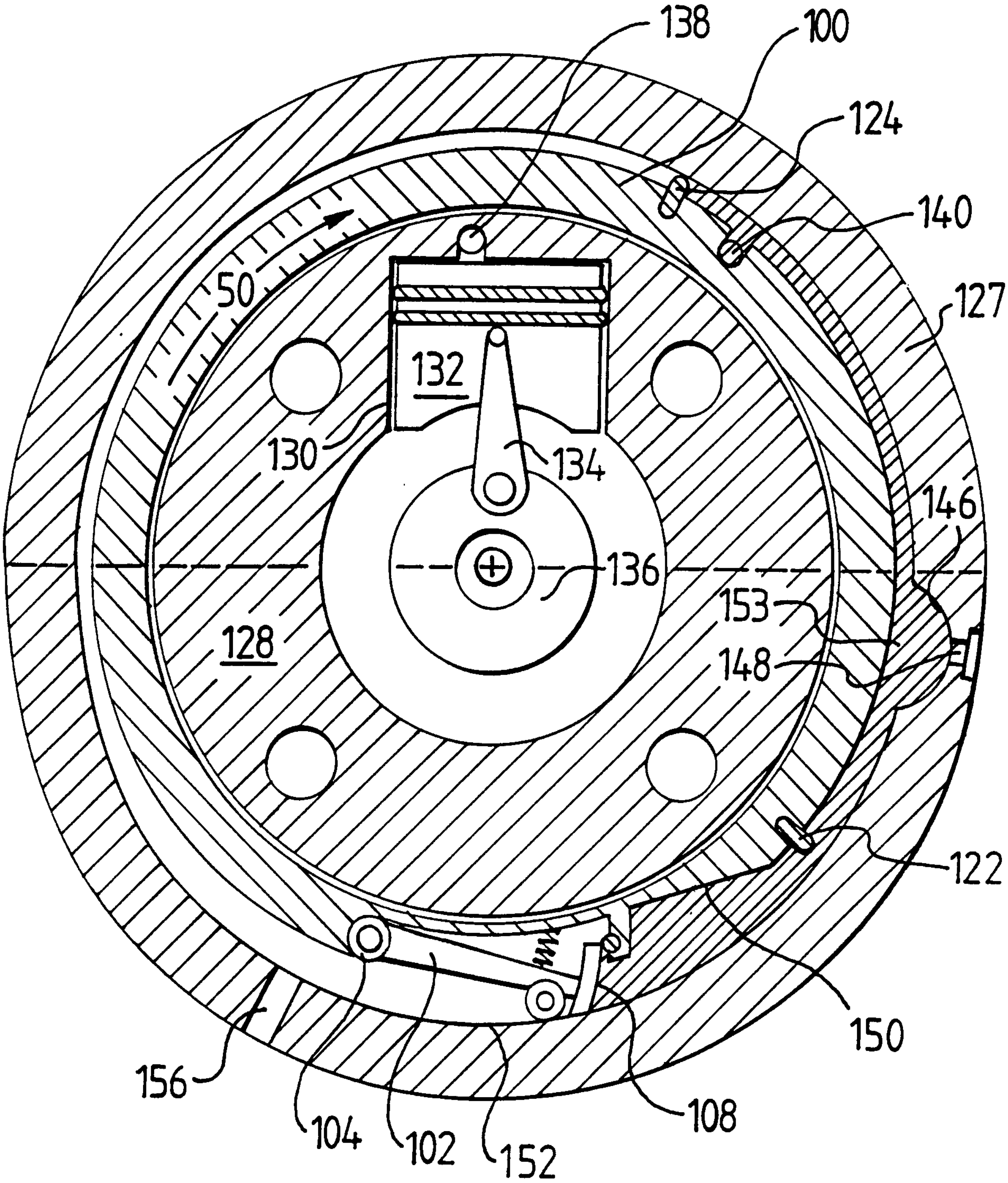
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FIG.3

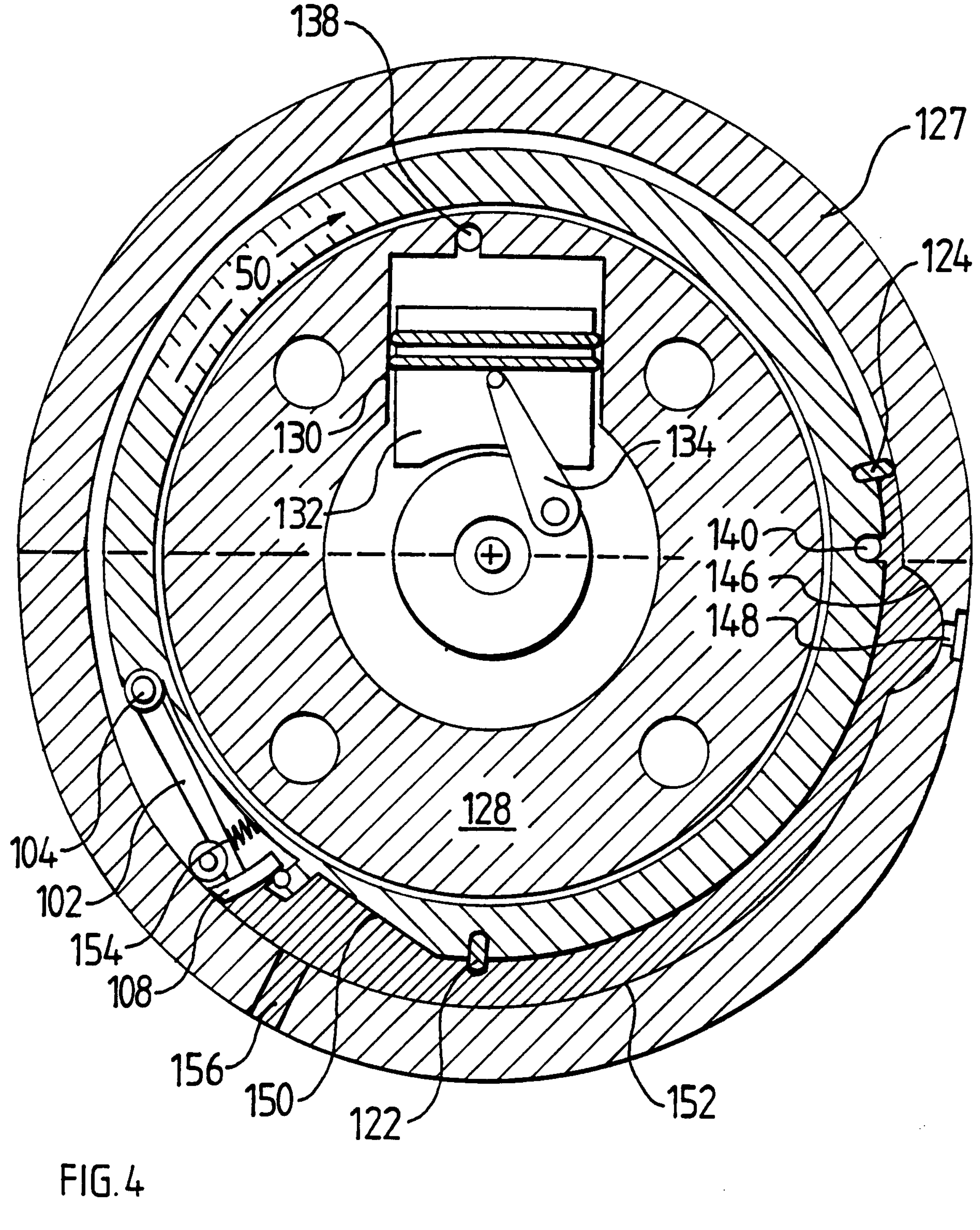
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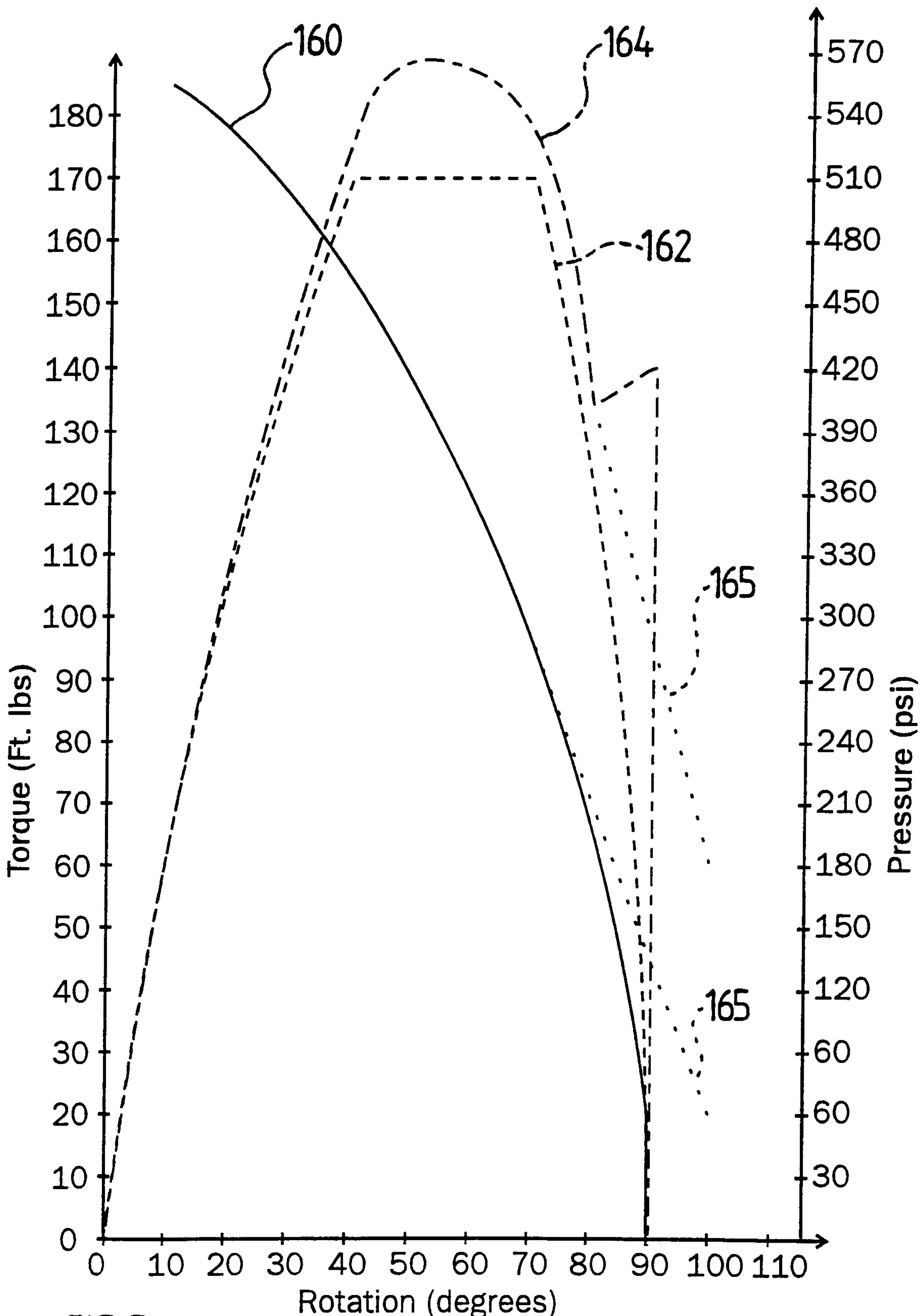
FIG.4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164
162
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165
Torque (Ft. lbs)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
Pressure (psi)
570
540
510
480
450
420
390
360
330
300
270
240
210
180
150
120
60
60
30
0 10 20 30 40 50 60 70 80 90 100 110
Rotation (degrees)

FIG. 5

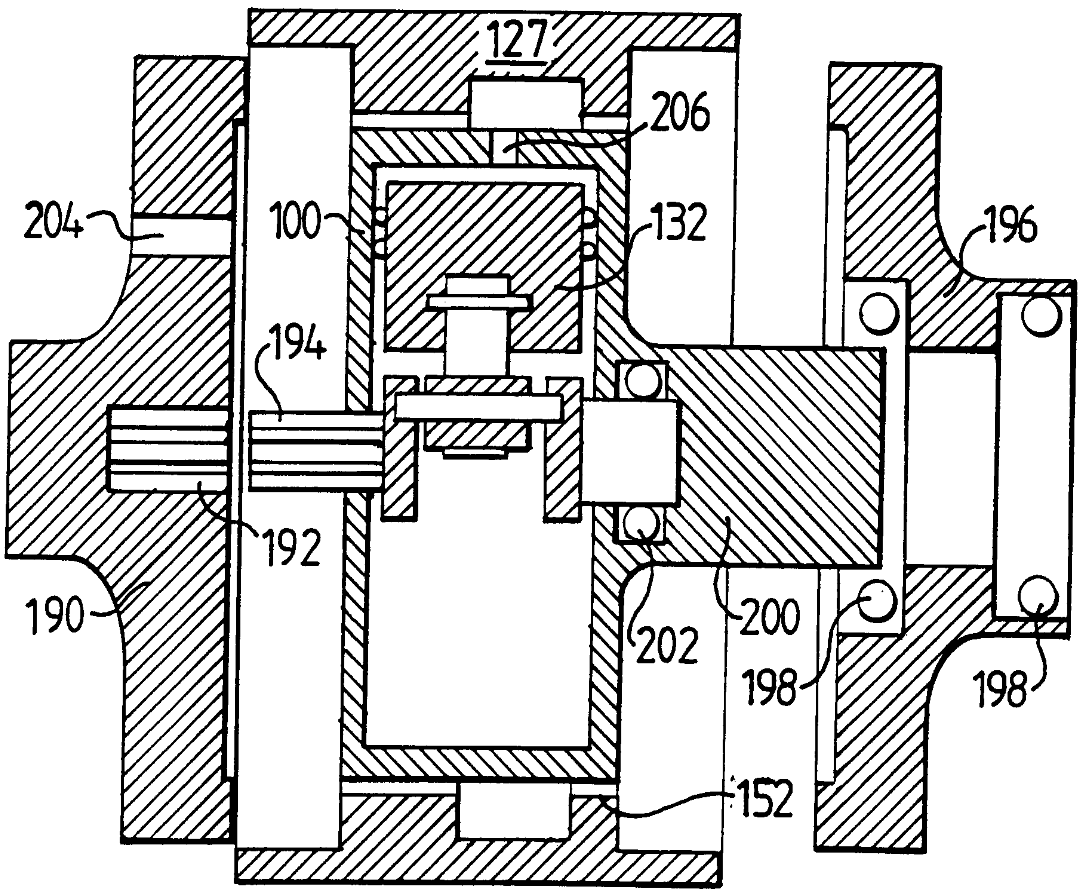

FIG.6

SUBSTITUTE SHEET

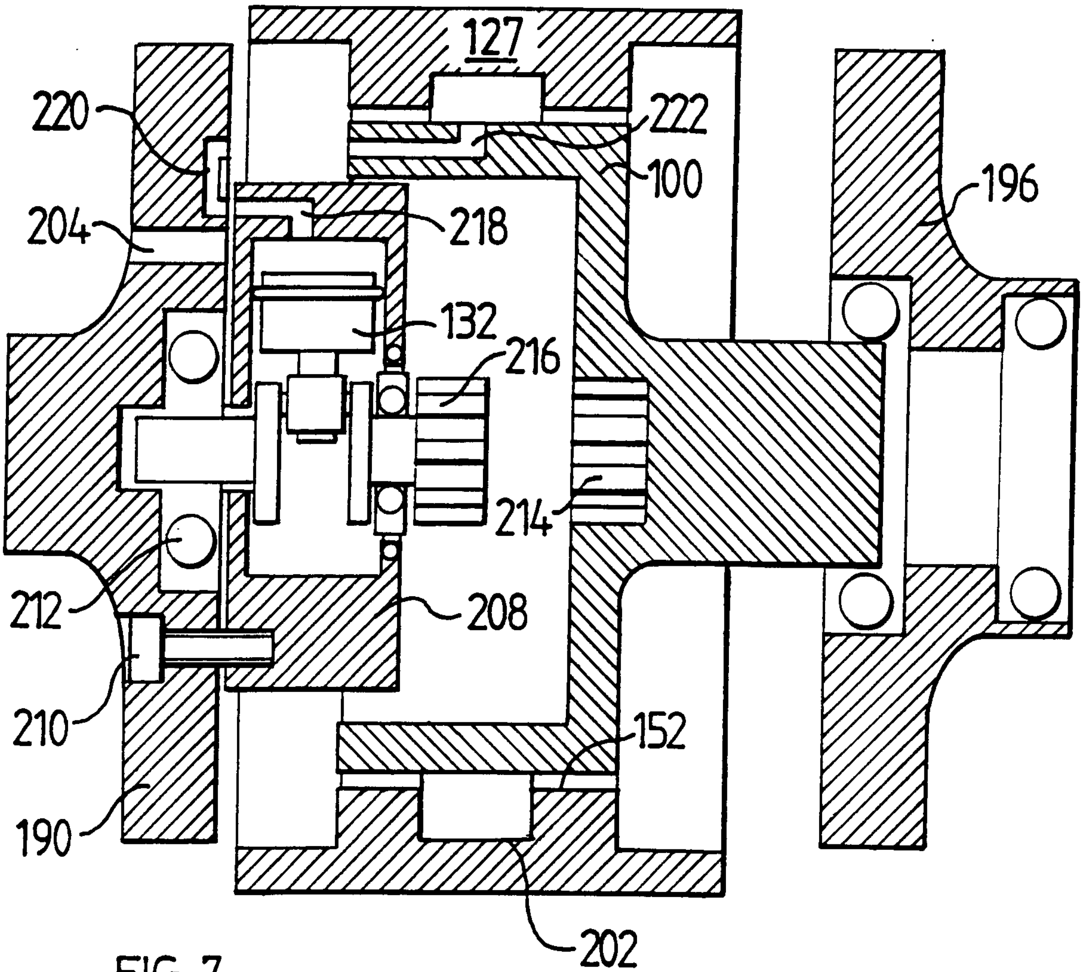

FIG. 7

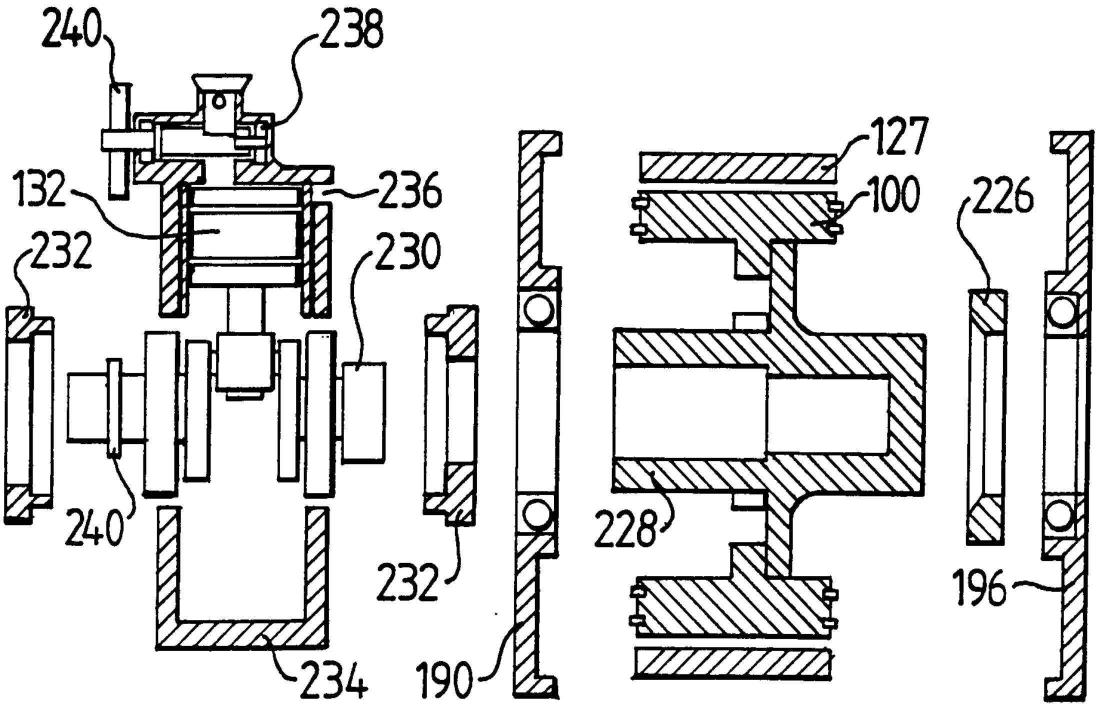

FIG.8

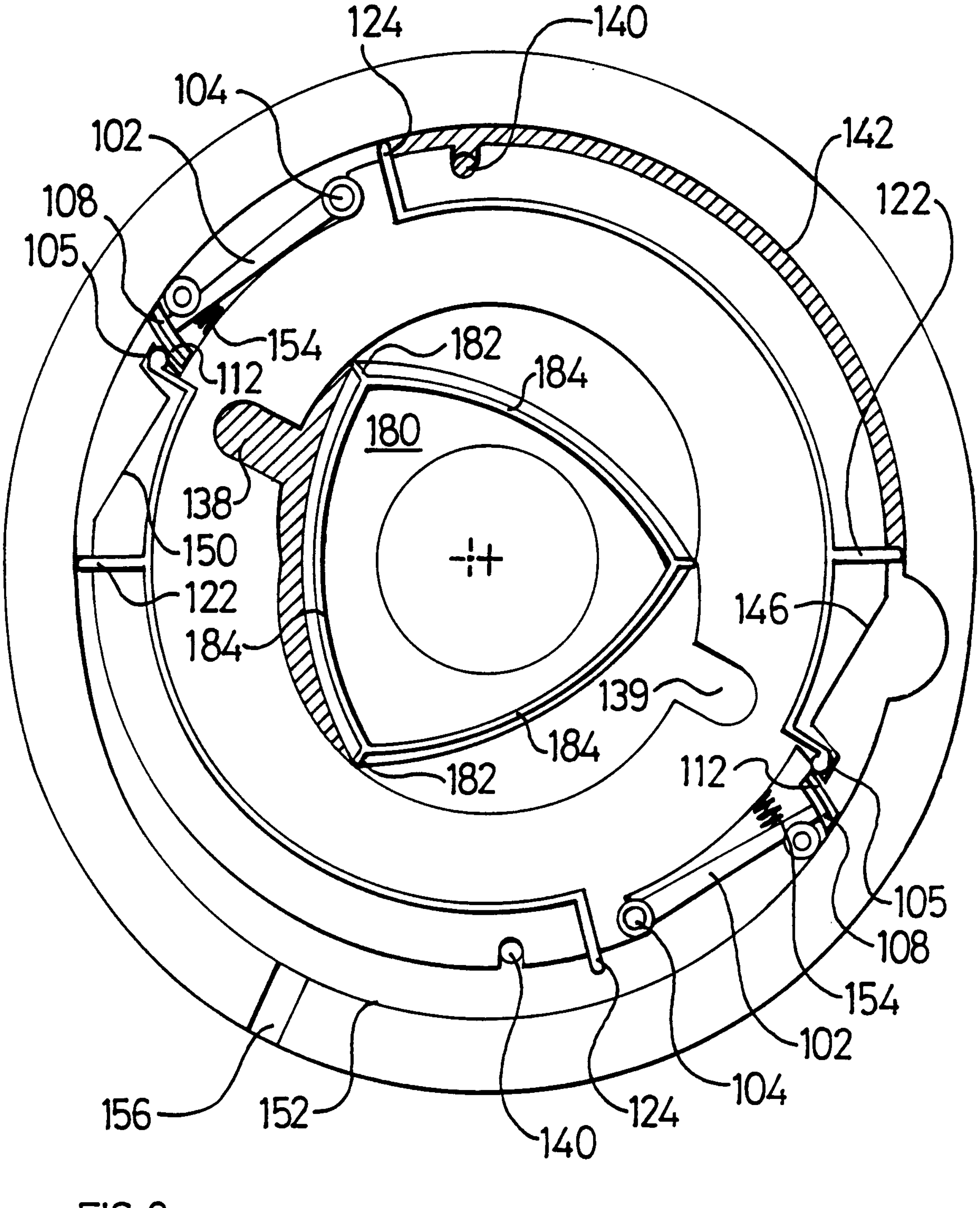
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FIG.9

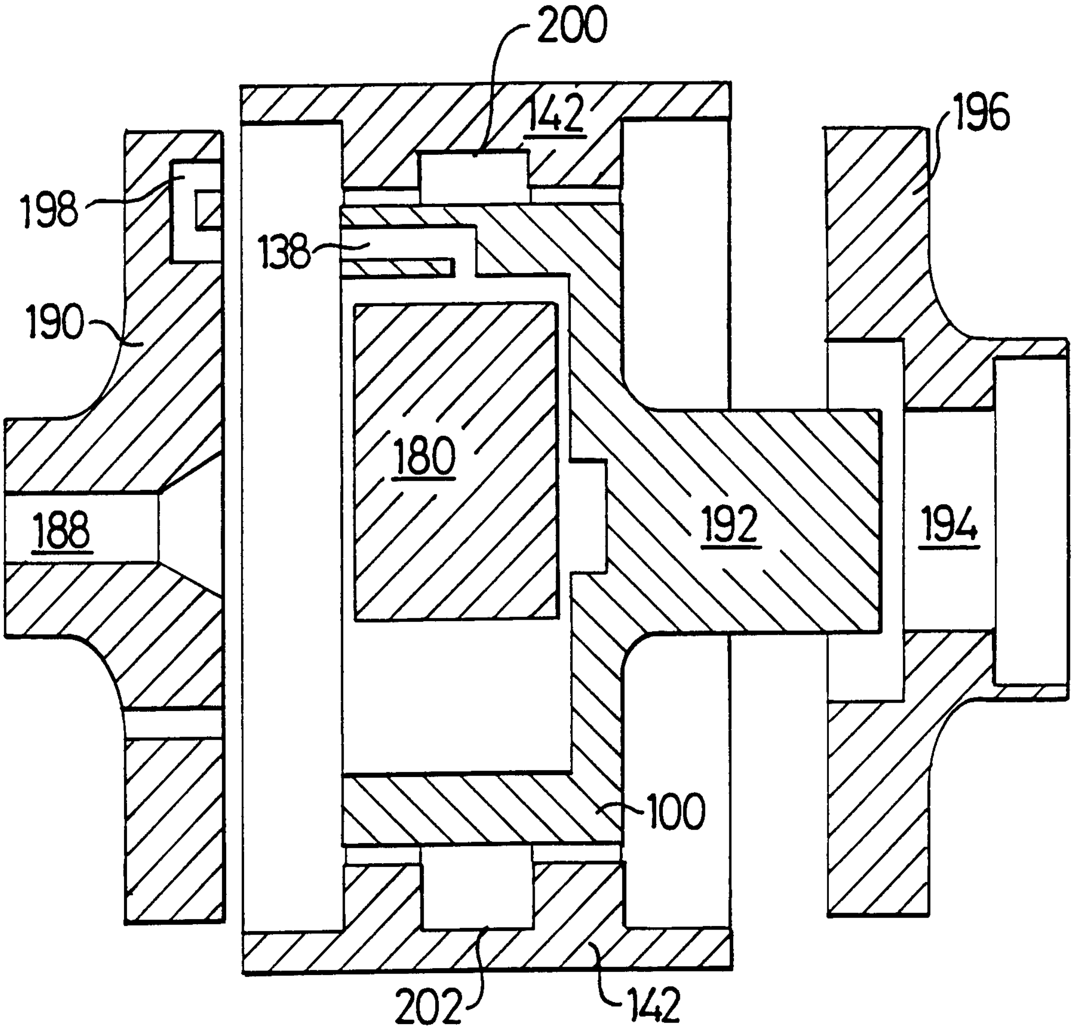

FIG.10

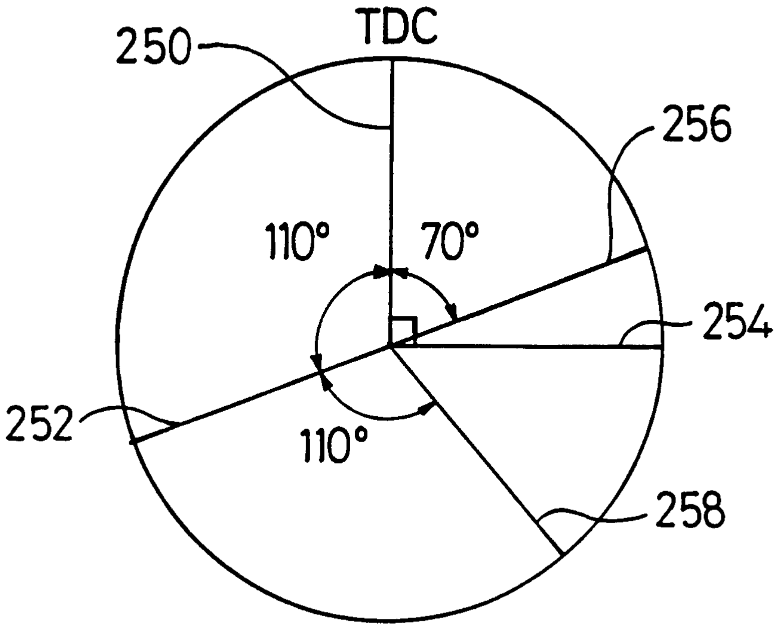

FIG.11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NZ 93/00123

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.^{5} F02B 53/00, 53/08, 55/14, F01C 1/44, 21/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC: F02B 53/00, 53/02, 53/08, 55/14, 33/02, 33/36, F01C 1/00, 1/44, 21/08

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
AU: IPC as above; Australian Classification 64.8

Electronic data base consulted during the international search (name of data base, and where practicable, search terms used)
DERWENT

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
X	FR,A,2651828 (LASSEE) 15 March 1991 (15.03.91) figure 1	1-10,19,28-31,33
X	Patent Abstracts of Japan, M-572, page 161, JP,A,61-241420 (HISAO AZEMI) 27 October 1986 (27.10.86) abstract	1-7,10,15,19-26, 28-31,33
Y		8-9
X	Patent Abstracts of Japan, M-116, page 27, JP,A,56-154101 (MUSASHI KAWAKAMI) 28 November 1981 (28.11.81) abstract	1-7,10-12,15,19-26, 28-31,33
Y		8-9

[X] Further documents are listed in the continuation of Box C.

[ ] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 March 1994 (14.03.94)	17 March 1994 (17.03.94)

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate of the relevant passages	Relevant to Claim No.
X	US,A,4389173 (KITE) 21 June 1983 (21.06.83) figure 1	1-12,15,19-26, 28-31,33
X	GB,A,2083557 (OSMOND) 24 March 1982 (24.03.82) figure 2, page 1 lines 3-22	1-7,10-12,15,19-26 28-31,33
X	DE,A,2606372 (SCHULTE) 1 September 1977 (01.09.77) figures 1 and 2	1-4,6-7,11-16, 19-26,28-31
X	AU,B,22291/45 (128784) (DEBNAM) 15 July 1948 (15.07.48) entire document	1-12,15,17,19-26,33

Supplementary Sheet - Box II Continued

- Claims 1-19, 28-31, 33 are directed to a rotary engine having a combustion chamber wall of variable area.

- Claims 20-26 are directed to a method of operating an engine in which gases are compressed in a first chamber and then transferred to a combustion chamber.

Since the above mentioned groups of claims do not share a common technical feature, a "technical relationship" as defined in PCT Rule 13.2 does not exist. Accordingly, the international application does not relate to one invention or to a single inventive concept.