United States Patent

[11] 3,537,432

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[21] Appl. No. 737,956
[22] Filed June 18, 1968
[45] Patented Nov. 3, 1970
[32] Priority June 21, 1967
[33] Republic of South Africa
[31] 67/3,696, 67/3,697, 67/3,698

[54] **ROTARY ENGINES**
16 Claims, 9 Drawing Figs.

[52] U.S. Cl. 123/8.41, 418/85,112,215,241
[51] Int. Cl. F02b 53/00
[50] Field of Search 123/8(MS) (SS)(MC), 16(B)(BA)(SA)(SC), 8(CC), 8.41; 103/144, 136; 91/121; 418/85, 112, 215, 241

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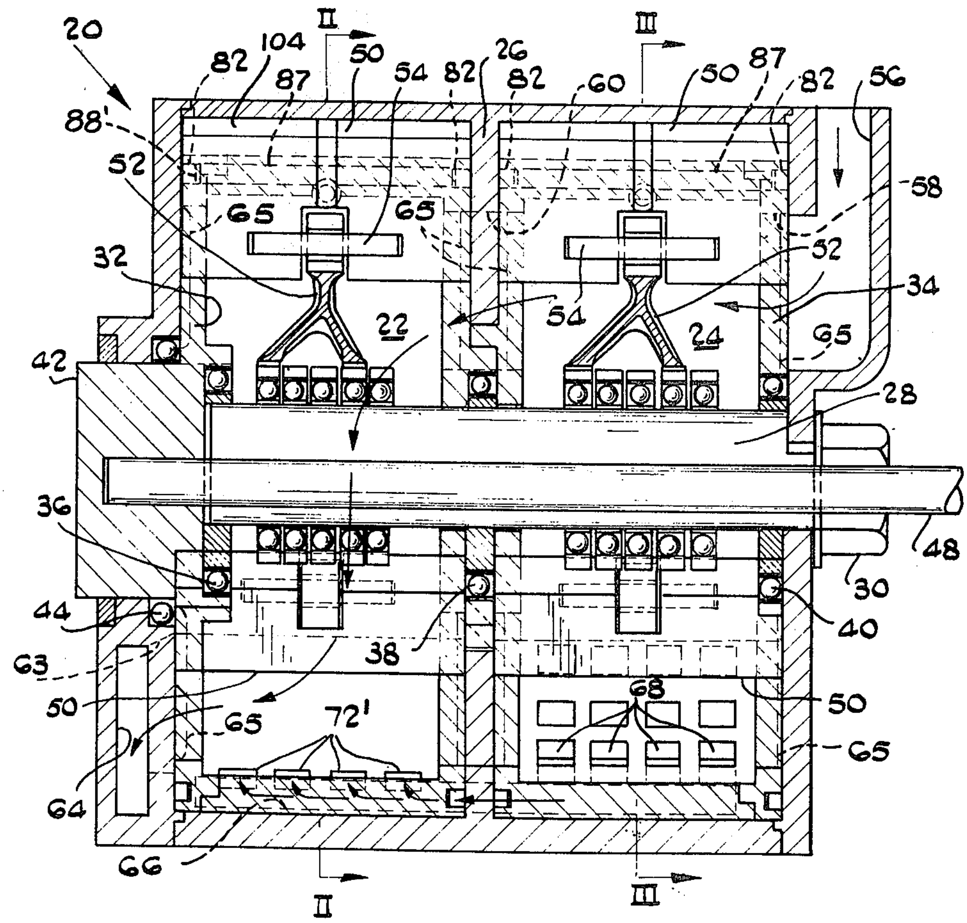
ABSTRACT: The present invention relates to positive displacement devices of the rotary type and in particular concerns internal combustion engines having an eccentrically mounte d rotor with radial blades slidable therein so as to form, with the external wall of the rotor and the internal wall of a casing surrounding it, a plurality of working chambers the respective volumes of which vary constantly during the rotation of the rotor said chambers being provided with inlet and outlet orifices.



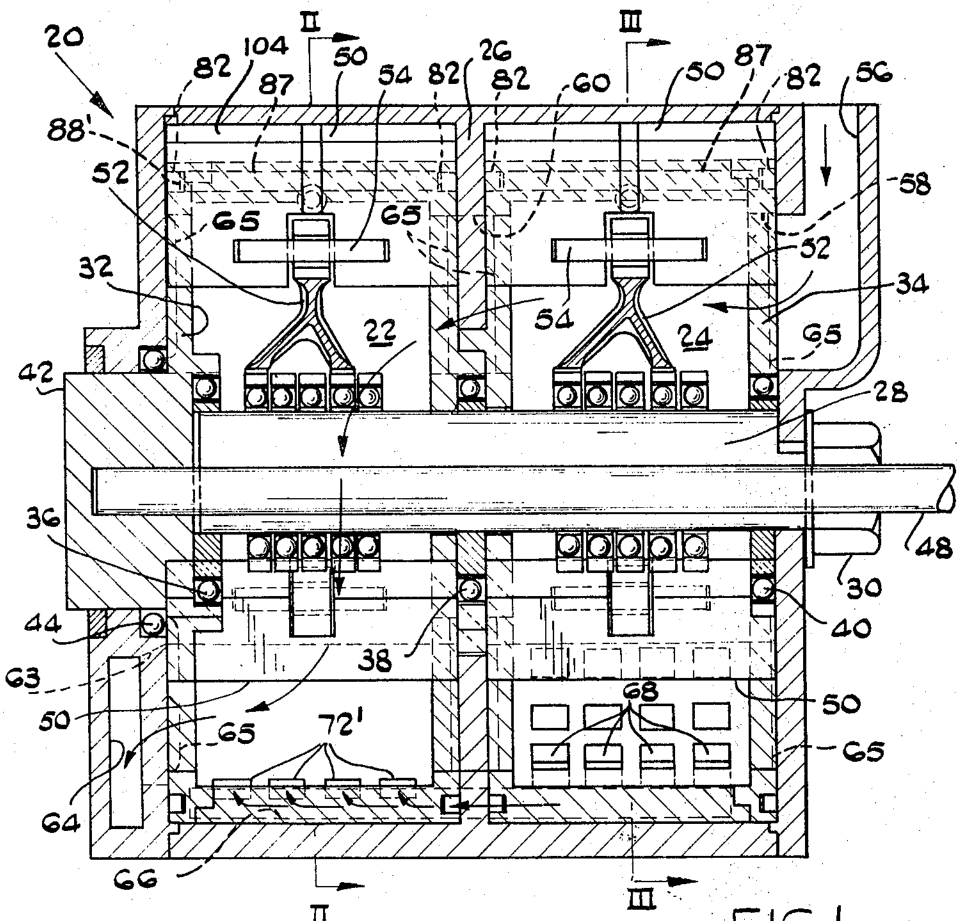


FIG. 1.

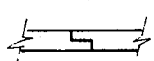


FIG. 9.

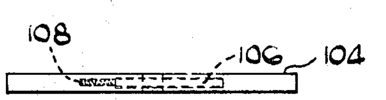


FIG. 8.

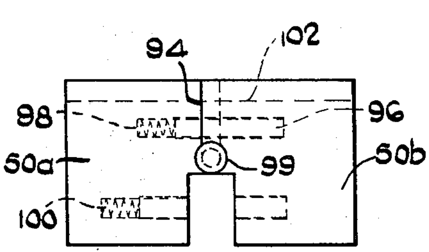


FIG. 6.

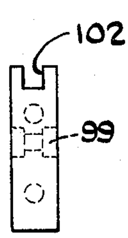


FIG. 7.

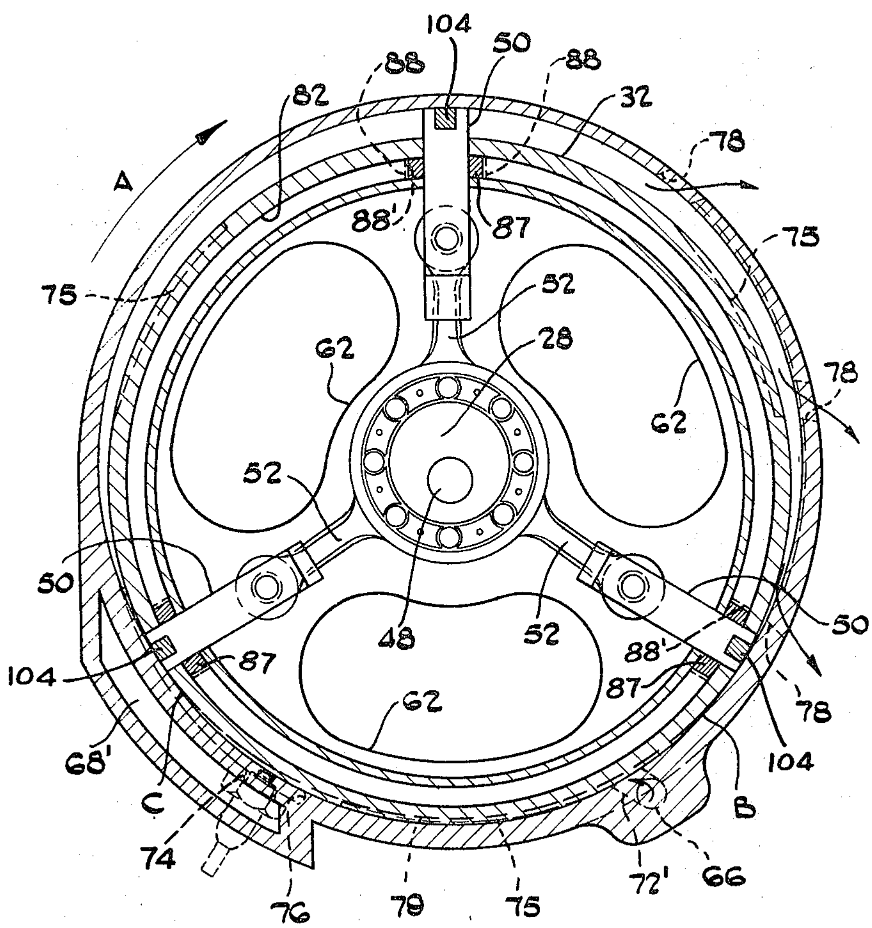

104
50
88
88
82
32
78
A
88'
87
75
75
52
28
62
78
62
52
50
50
104
87
48
52
88'
87
78
62
104
68'
C
B
74
76
79
75
72'
66

FIG. 2.

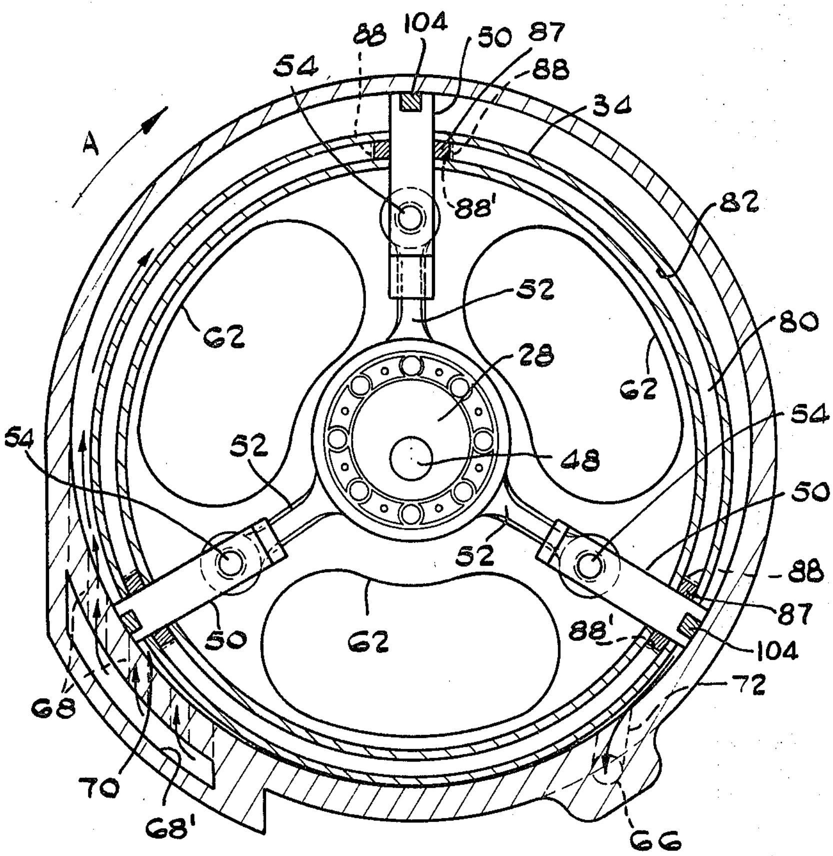


FIG. 3.

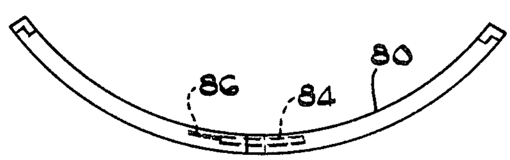


FIG. 4.

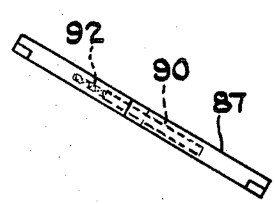


FIG. 5.

ROTARY ENGINES

An object of the invention is to provide a machine of this kind which is more efficient than those in use up to the present time. For this purpose the machine according to the invention comprises a rotor in the form of a body symmetrical about an axis and rotatable about said axis, said rotor having mounted therein a plurality of radial blades each slidable in the rotor in a plane passing through said axis, said blades cooperating with a casing surrounding the rotor, and in that a plurality of links are interposed between said blades respectively and the shaft or spindle extending along a second axis parallel to the first mentioned one to control the sliding movements of the blades in the rotor, the casing disposed about said rotor being in the form of a surface surrounding, with small clearance, the surface generated by the outer edges of the said blades when the rotor is rotating in a fixed casing. According to the invention the rotor is of hollow drum form so that a gaseous substance such as an air-fuel mixture for the engine is capable of being circulated within the rotor drum. By including a lubricant in finely divided form with the air-fuel mixture the internal parts of such rotor are capable of thus being lubricated. A further feature of the invention is the provision of an internal combustion engine comprising one casing and rotor unit as above described constituting the engine proper, with a second casing and rotor unit as above described coupled to the first mentioned unit and acting as a compressor for feeding an air-fuel mixture under pressure into the working chambers of the unit constituting the engine.

SUMMARY

This invention relates to positive displacement devices of the rotary type and includes internal combustion engines, compressors, pumps, motors, steam engines and the like of the general type comprising a hollow stator within which is rotatably mounted a rotor eccentric to said stator having vanes associated therewith, the outer ends of which cooperate with the interior of the hollow stator to form working chambers, the volumes of which vary as the rotor rotates.

According to the invention a positive displacement device of the rotary type referred to includes, a stator casing having a substantially cylindrical hollow interior providing a rotor chamber, a stationary main shaft coaxial with the interior curved surface of the stator casing and extending through it, a rotor in the form of a hollow drum mounted for rotation about an axis parallel with stator axis but displaced from it, a plurality of circumferentially spaced and substantially radially disposed vanes extending slidably and sealingly through transverse radial slots in the peripheral wall of the rotor, which vanes are each pivotally connected to an arm and which arms are in turn pivotally mounted on the main shaft so that the outer end of each vane is constrained, on rotation of the rotor, to rotate around a path coinciding with small clearance with the interior curved surface of the rotor chamber, whereby variable volume working chambers are formed between adjacent vanes, the outer curved surface of the rotor, and the inner curved surface of the rotor chamber, inlet and outlet means for admitting working or displacement fluid to the working chambers, as well as inlet and outlet means for admitting lubricant in finely divided form to the interior space of the rotor. The finely divided lubricant may be admitted to the interior space of the rotor by being entrained in a gaseous fluid such as air, which may act additionally as cooling means.

According to the invention a rotary internal combustion engine comprises a stator casing having a substantially cylindrical hollow interior which is divided into at least two rotor chambers by an annular partition extending inwardly from the stator casing, a stationary main shaft coaxial with the interior curved surface of the stator casing extending through substantially the whole length thereof, a rotor in the form of a hollow drum, mounted, one within each of the two rotor chambers for rotation about an axis parallel with the axis of the stator casing but displaced from it, a plurality of circumferentially spaced and substantially radially disposed vanes extending slidably and sealingly through transverse radial slots in the peripheral wall of each rotor, which vanes are each pivotally connected to an arm and which arms are in turn pivotally mounted on the main shaft so that the outer end of each vane is constrained, on rotation of its rotor, to rotate around a path coinciding with small clearance with the substantially circular interior curved surface of a rotor chamber, whereby variable volume working chambers are formed between adjacent vanes, the outer curved surface of a rotor, and the inner curved surface of a rotor chamber, wherein the two rotors are connected together so that they rotate in unison, wherein one rotor chamber with its rotor and associated vanes is constituted to act as a power unit, while the other rotor chamber with its rotor and associated vanes, is constituted to act as a compressor unit, arranged to compress a combustible fuel-air mixture supplied to it and to feed it in compressed condition to the power unit through suitably disposed transfer passages and inlet ports provided in the stator casing, so that it enters a working chamber of the power unit just prior to its ignition therein to provide a power stroke.

The interior spaces of the two hollow drumlike rotors are in direct communication with one another by way of ports in the annular partition separating them.

It is a feature of the invention that lubrication of the internal working parts is effected by projecting a liquid lubricant, in finely divided form, into the interior spaces of the rotors in a substantially continuous manner so that under the action of centrifugal force, the lubricant is distributed to such internal working parts. One method of achieving this is to project the finely divided lubricant into such interior spaces entrained with air. Another method is to mix the finely divided lubricant with a combustible fuel-air mixture supplied to the engine by way of an inlet opening passing through an end wall of the rotor chamber of the compressor unit, so that it passes through the interior spaces of both rotors before it is transferred to the variable volume working chambers of the compressor unit and thereafter to the variable volume working chambers of the power unit through suitably disposed transfer passages. This inward circulatory flow of the fuel-air mixture carrying a lubricant is caused by suction created in the working chambers of the compressor unit when in certain positions. By this provision the fuel-air mixture plus lubricant acts additionally as cooling means for the internal working parts, and the rotor chambers.

According to a further feature of the invention, the periphery of the rotor in the case of the power unit, is arranged to make substantial surface sealing contact across the inner surface of its rotor chamber in a position just rearwardly of a working chamber when such chamber is a reduced volume to provide a combustion chamber for the commencement of a power stroke. This is achieved by providing a shallow arcuate recess in the inner surface of the rotor chamber, having a curvature corresponding to the curvature of the periphery of the rotor. By this provision back pressure on an immediately following vane is substantially avoided whereby the efficiency of the power unit is improved. A tapered or wedge-shaped combustion recess is preferably provided in the inner surface of the rotor chamber in a position to coincide with a working chamber when reduced in volume to provide a combustion chamber as described above.

To enable the compressed fuel air mixture to pass to the tapered or wedge-shaped combustion recess from the inlet port, transfer recesses are provided in the outer peripheral surface of the rotor in the region between the vanes, which recesses as they pass the inlet port are filled with compressed fuel air mixture which is admitted to the combustion recess as each transfer recess rotates past and comes into communication with it. By this provision back pressure is substantially avoided.

In the case of an internal combustion engine requiring means for igniting the combustible fuel-air mixture, such as a sparking plug, such ignition means is conveniently arranged to

project into or communicate directly with the above described combustion recess. Transfer conduit means from the compressor unit is connected to this combustion recess, so that a charge of compressed fuel-air mixture is projected into the working chamber from the compressor unit in the required timed relationship with respect to the successive positions of the vanes of the power unit.

To provide sealing means in each rotor, arcuate sealing elements are arranged to be inserted in correspondingly shaped grooves in the edges of the two ends thereof, between each vane-accommodating transverse radially directed slot in the peripheral wall thereof, the ends of which arcuate sealing elements form right-angled joints with the ends of straight sealing elements which are located in grooves formed one in each of the two opposing side walls of each of the aforesaid vane-accommodating transverse radially directed slots, so that they bear sealingly against each face of a vane. The arcuate sealing elements bear sealingly against the interior side walls of the rotor chambers. Both the arcuate and the straight sealing elements are in two parts with resilient means tending to force such parts outwardly. By this provision each of these types of sealing element holds the other in resilient sealing engagement with the respective surfaces with which they make sliding contact. The resilient means is preferably a compression spring located within each sealing element. In addition spring means such as a corrugated strip type spring is provided behind the arcuate and straight sealing elements.

Similarly, to hold the two opposing ends of a vane in sealing contact with the interior-opposing side wall surfaces of its rotor chamber, each vane is made in two half parts slidably and sealingly jointed at their abutting edges and provided with resilient means tending to separate the two half parts, so that their opposing end surfaces are at all times resiliently pressed into sealing contact with the interior opposing side wall surfaces of the rotor chamber. Similarly also, the outer end of each vane is grooved to receive a straight sealing element which is also in two parts with spring means tending to separate the two parts, and thereby to hold their ends in resilient sealing contact with the interior opposing side wall surfaces of the rotor chamber. Spring means may be used to hold these sealing elements in sealing contact with the inner substantially circular surface of a rotor chamber.

To enable the invention to be more clearly understood and carried into practice, reference is now made to the accompanying drawings in which:

FIG. 1 is a part cross-sectional view of an internal-combustion engine constructed according to the invention;

FIG. 2 is an end part cross-sectional view of the power unit of the engine of FIG. 1, taken on line II–II of FIG. 1;

FIG. 3 is an end part cross-sectional view of the compressor unit of the engine of FIG. 1 taken on line III–III of FIG. 1;

FIG. 4 is an elevation of the arcuate sealing element for the ends of a rotor;

FIG. 5 is an elevation of the straight sealing element arranged to be located one on each side of a vane;

FIG. 6 is an elevation of a preferred form of vane made in two parts;

FIG. 7 is an end view taken on FIG. 6;

FIG. 8 is an elevation of the two-part sealing element arranged for insertion in a slot in the outer end of the vane of FIG. 6; and

FIG. 9 is a fragmentary view showing the joint between the two parts of the sealing element of FIG. 8.

Referring to the drawings, reference **20** denotes the stator casing which is divided into two rotor chambers **22** and **24** by the inwardly directed annular partition **26**. A stationary main shaft **28** extends from end to end of the stator casing **20** and its projecting screw-threaded end is secured by the external nut **30**. The rotor **32** of the power unit which is of hollow drum form, is rotatably mounted in the rotor chamber **22** while the similar hollow rotor **34** of the compressor unit, is rotatably mounted in the rotor chamber **24**. The rotors **32** and **34** are secured together so that they rotate in unison about an axis

parallel to the axis of the main shaft **28**, but displaced from it, so that both rotors are mounted eccentrically within their respective rotor chambers **22** and **24**, by being mounted on the three ball bearings **36**, **38** and **40**. The rotor **32** of the power unit is connected to a power takeoff boss or flywheel **42** mounted in a ball bearing **44**. An auxiliary shaft **48** is keyed by one end to the power takeoff boss or flywheel **42** and extends rotatably through an eccentric bore in the main shaft **28** acting as a bearing, and may be used for driving engine auxiliaries such as a generator, fuel pump, cooling fan or the like.

Each of the two rotors **32** and **34** is provided with three vanes **50** which extend slidably through transverse slots in the peripheral wall of each rotor as clearly shown in FIGS. **2** and **3**. Each vane **50** is pivotally connected to an arm **52** by a pivot pin **54**, and the arms **52** are in turn pivotally mounted on the main shaft **28** by ball bearings as shown, so that as they rotate in association with their respective rotors, the outer ends of the vanes rotate with small clearance with respect to the substantially circular inner surfaces of their respective rotor chambers. Each vane **50**, which is of rectangular flat blade form as shown, is provided with a slot in its outer edge in which a sealing element such as that shown more clearly in FIGS. **8** and **9**, is slidably located, so that by reason of balanced spring-loaded action it is pressed into sliding sealing contact with the inner surface of a rotor chamber, so that variable volume working chambers are formed between adjacent vanes, the outer surface of a rotor and the inner surface of a rotor chamber.

The vanes **50** are mounted on the main shaft **28** by the ball bearings as shown, so that each is capable of independent movement. Two vanes are connected to different outer pairs of ball bearings, while the third is connected to the centre ball bearing of the five shown.

An inlet for the fuel-air mixture is located on the outer side of the compressor unit and is denoted by reference **56**. An inlet port **58** is provided in the end wall of the stator casing **20** to lead fuel-air mixture into the interior space of the hollow rotor **34** through the apertures **62** in the side walls of the rotor **34**. Further ports **60** are provided in the partition **26** leading into the interior space of the hollow rotor **32** via its apertures **62**. A port **63** in the opposite end of the stator casing **20** is provided leading into an outer conduit **64**, which extends across the width of the stator casing **20** and then lengthwise to conduit **68'** to place the interior spaces of the hollow rotors **34** and **32** in communication with suction inlet ports **68** in the stator casing **20** which, communicate with the suction working chamber **70** of the compressor unit as shown in FIG. **3**. The fuel-air mixture having been sucked into the compressor unit is compressed therein and is then transferred to the power unit by way of ports **72** leading into a transverse transfer passage **66** in the stator casing which leads in turn to ports **72'** communicating with the working chamber of the power unit as shown in FIG. **2**. To facilitate the passage and distribution of the fuel-air mixture within the hollow rotors **32** and **34**, a concentric annular recess **65** may be provided in the ends of the two rotors **32** and **34**.

It is to be noted that at the lower region of the stator chamber **22** between the points B and C, the periphery of the rotor **32** makes sealing or near-sealing contact with its working chamber, by providing a shallow arcuate recess **79** in the inside surface of the rotor chamber.

Adjacent to point C a wedge-shaped recess **76** providing a combustion chamber is provided in the curved surface of the stator chamber **22**. To enable compressed fuel-air mixture in the transfer passage **66** to be fed to this combustion chamber, three equally spaced wedge-shaped transfer recesses **75** are provided in the periphery of the rotor **32** between the vanes **50**. As these recesses **75** rotate past the ports **72'**, each in turn fills with a charge of compressed fuel-air mixture which charges are transferred in turn to the combustion chamber **76** where they are ignited successively by ignition means such as a sparking plug projecting into the combustion chamber **76** via an opening **74**. Each working stroke propels a vane **50**, and with it the rotor 32, in the direction of the arrow A, while the exhaust gasses carried around in front of each vane 50 are discharged via the three exhaust ports 78 to complete a working cycle. The above arrangement avoids to a substantial degree the subjection of following vanes to back pressure.

For lubrication purposes a liquid lubricant is mixed with the fuel-air mixture so that by means of the arrangement as above described, all the working parts of both the compressor unit and the power unit are continuously lubricated when the engine is running.

FIG. 4 shows a preferred construction of arcuate sealing element 80 for insertion in arcuate slots 82 provided in the opposite ends of each of the rotors 32 and 34. As shown the element 80 is made in two half parts connected by a rebated joint and a locating pin 84 with a small compression spring 86 tending to separate the two half parts. Coacting with these arcuate sealing elements are the straight sealing elements 87 of FIG. 5, which are located in transverse slots 88 provided in opposite sides of the slotted openings through which the vanes 50 project. These sealing elements 87 are similar in construction to the arcuate sealing elements 80 in that they are constructed in two half parts connected by a rebated joint, a locating pin 90 and a compression spring 92.

Each end of an arcuate sealing element 80 engages with an end of a straight sealing element 87 by way of a rebated interlocking joint as shown, whereby the arcuate sealing elements 80 press the straight sealing elements 87 into resilient sealing contact with opposite sides of each vane 50, and similarly the straight sealing elements 87 press the arcuate sealing elements 80 into resilient sealing contact with the sides of the rotor chambers.

Additionally corrugated strip springs 88' are located in the arcuate slots 82 behind the arcuate sealing elements 80 and in the slots 88 behind the straight sealing elements 87.

Reference is now made to FIGS. 6, 7, 8 and 9 showing the preferred sealing provisions applied to each vane 50, which are similar in certain respects to the provisions applied to the sealing elements 80 and 87 above described. Here again each vane is made up of two half parts 50*a* and 50*b* which are joined by a rebated joint 94 and are held in alignment by a locating pin 96 and are resiliently pressed apart by a compression spring 98 so that the outer ends, at all times are resiliently pressed into sealing contact with the side or end surfaces of a rotor chamber. The pivot pin 54 may be held in position by a compression spring 100 in order to achieve equal resilient pressure as above. A pin 99 holds the parts 50*a* and 50*b* slidably together.

The outer edge of a vane is provided with a slot 102 into which a straight sealing element 104 is slidably insertable. Here again this sealing element is made up of two half parts jointed by a rebated joint and held in alignment by a locating pin 106. As before a compression spring 108 tends to press the two half parts resiliently apart so that their ends are pressed into resilient sealing contact with the side or end surfaces of a rotor chamber.

Centrifugal force ensures sealing contact is maintained with the inner curved surface of a rotor chamber. This may be assisted by spring means.

We claim:

1. A rotary internal combustion engine which includes two rotor chambers and a vane carrying rotor mounted rotatably and eccentrically within each rotor chamber, the rotors being coaxial and a first rotor and chamber combination functioning as a compressor and delivering a compressed charge to the second rotor and chamber combination which functions as a power unit in which the compressed charge is ignited, the rotors having hollow interiors in communication with one another whereby air being drawn into the compressor passes through the communicating hollow interiors of the rotors prior to compression by said first rotor.

2. A rotary internal combustion engine according to claim 1 in which the first and second rotor chambers are separated from one another by an interior partition, the interior partition and transverse end walls of the chambers having ports therein, the port in one of said transverse walls is adjacent the first rotor communicating with an inlet and with the hollow interior of the first rotor, and the port in the other transverse end wall communicating with the hollow interior of the second rotor and with the first rotor and chamber combination to supply air for compression thereto.

3. A rotary internal combustion engine according to claim 2 in which lubrication of the internal working parts is effected by projecting a liquid lubricant, in finely divided form, into the interior spaces of the rotors in a substantially continuous manner so that under the action of contrifugal force, the lubricant is distributed to such internal working parts.

4. A rotary internal combustion engine according to claim 3 wherein the finely divided lubricant is mixed with a combustible fuel-air mixture supplied to the engine by way of said inlet.

5. A rotary internal combustion engine according to claim 1 wherein the periphery of the second rotor is arranged to make substantial surface sealing contact across the inner surface of its rotor chamber in a position just rearwardly of a working chamber when such chamber is of reduced volume to provide a combustion chamber for the commencement of a power stroke.

6. A rotary internal combustion engine according to claim 5 wherein a shallow arcuate recess is provided in the inner surface of the rotor chamber, said chamber having a curvature corresponding to the curvature of the periphery of the rotor.

7. A rotary internal combustion engine according to claim 1 having a tapered or wedge-shaped combustion recess in the inner surface of said second rotor chamber in a position to coincide with a working chamber when reduced in volume to provide a combustion chamber.

8. A rotary internal combustion engine which comprises a stator casing having a substantially cylindrical hollow interior which is divided into at least two rotor chambers by an annular partition extending inwardly from the stator casing, a stationary main shaft coaxial with the interior curved surface of the stator casing extending through substantially the whole length thereof, a rotor in the form of a hollow drum, mounted, one within each of the two rotor chambers for rotation about an axis parallel with the axis of the stator casing but displaced from it, a plurality of circumferentially spaced and substantially radially disposed vanes extending slidably and sealingly through transverse radial slots in the peripheral wall of each rotor, which vanes are each pivotally connected to an arm and which arms are in turn pivotally mounted on the main shaft so that the outer end of each vane is constrained, on rotation of its rotor, to rotate around a path coinciding with small clearance with the substantially circular interior curved surface of a rotor chamber, whereby variable volume working chambers are formed between adjacent vanes, the outer curved surface of a rotor, and the inner curved surfaces of a rotor chamber, wherein the two rotors are connected together so that they rotate in unison, wherein one rotor chamber with its rotor and associated vanes is constituted to act as a power unit, while the other rotor chamber with its rotor and associated vanes, is constituted to act as a compressor unit, arranged to compress a combustible fuel-air mixture supplied to it and to feed it in compressed condition to the power unit through suitably disposed transfer passages and inlet ports provided in the stator casing, so that it enters a working chamber of the power unit just prior to its ignition therein to provide a power stroke, there being a tapered or wedge-shaped combustion recess provided in the inner surface of the one rotor chamber in a position to coincide with a working chamber when reduced in volume to provide a combustion chamber, and wherein to enable the compressed fuel-air mixture to pass to the tapered or wedge-shaped combustion recess from the inlet port, transfer recesses are provided in the outer peripheral surface of the rotor in the region between the vanes, which recesses as they pass the inlet port are filled with compressed fuel-air mixture which is admitted to the combustion recess as each transfer recess rotates past and comes into communication with it.

9. A rotary internal combustion engine according to claim 8 in which in the combustion recess is provided with a means for igniting the combustible fuel-air mixture, such ignition means is arranged to project into or communicate directly with the said tapered or wedge-shaped combustion recess.

10. A rotary internal combustion engine according to claim 9 wherein the ignition means is a spark plug.

11. A rotary internal combustion engine according to claim 8 in which arcuate sealing elements are arranged to be inserted in correspondingly shaped grooves in the edges of the two ends thereof, between each vane-accommodating transverse radially directed slot in the preipheral wall thereof, the ends of which arcuate sealing elements form right-angled joints with the ends of straight sealing elements which are located in grooves formed one in each of the two opposing side walls of each of the aforesaid vane-accommodating transverse radially directed slots bearing sealingly against each face of a vane.

12. A rotary internal combustion engine according to claim 11 in which both the arcuate and the straight sealing elements are in two parts with resilient means tending to force such parts outwardly whereby each of these types of sealing element holds the other in resilient sealing engagement with the respective surfaces with which they make sliding sealing contact.

13. A rotary internal combustion engine according to claim 12 in which said resilient means is a compression spring located within each sealing element.

14. A rotary internal combustion engine according to claim 13 wherein an additional spring means such as a corrugated strip-type spring is provided behind the arcuate and straight sealing elements in addition to said resilient spring means.

15. A rotary internal combustion engine according to claim 8 wherein each vane is made in two half parts slidably and sealingly jointed at their abutting edges and provided with resilient means tending to separate the two half parts, so that their opposing end surfaces are at all times resiliently pressed into sealing contact with the interior opposing side wall surface of the rotor chamber thereby holding the two opposing ends of a vane in sealing contact with the interior opposing side wall surfaces of its rotor chamber.

16. A rotary internal combustion engine according to claim 15 in which the outer end of each vane is grooved to receive a straight sealing element which is also in two parts with spring means tending to separate the two parts, and thereby holding their ends in resilient sealing contact with the interior opposing side wall surfaces of the rotor chamber.