United States Patent [19]

Gordon

[11] **3,924,980**

[45] **Dec. 9, 1975**

[54] **LOW FRICTION, CONTROLLED LEAKAGE ROTARY ENGINE**

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[22] Filed: **Aug. 1, 1974**

[21] Appl. No.: **493,720**

[52] **U.S. Cl.** **418/191**; 418/227

[51] **Int. Cl.²** **F01C 1/08**

[58] **Field of Search** 418/191, 227; 73/261

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[57] **ABSTRACT**

A rotary engine for use as a fluid motor or pump which employs a rotor carrying pistons that are adapted to rotate within a circular chamber. A working fluid is introduced into and exhausted from the chamber through inlet and outlet ports provided on opposite sides of a rotary blocking valve. The blocking valve is formed with a concaval recess and is driven to turn conjointly with the pistons so that the latter are successively enveloped within and move across the blocking valve. The inlet port and blocking valve are arranged to provide an effective pressure stroke of greater than 120° for a three piston engine to prevent stalling and deadspots in the engine's operation. The engine is dynamically balanced for high speed operation in the manner of a turbine. Close-spaced, frictionless clearance between the piston and chamber walls is provided. Fluid leaks at a controlled rate around the pistons to form a backpressure in the trapped volume ahead of the pressurized volume. Fluid leakage around the rotor is controlled due to back pressure developed in the pressure sealed housing enclosing the elements.

14 Claims, 6 Drawing Figures

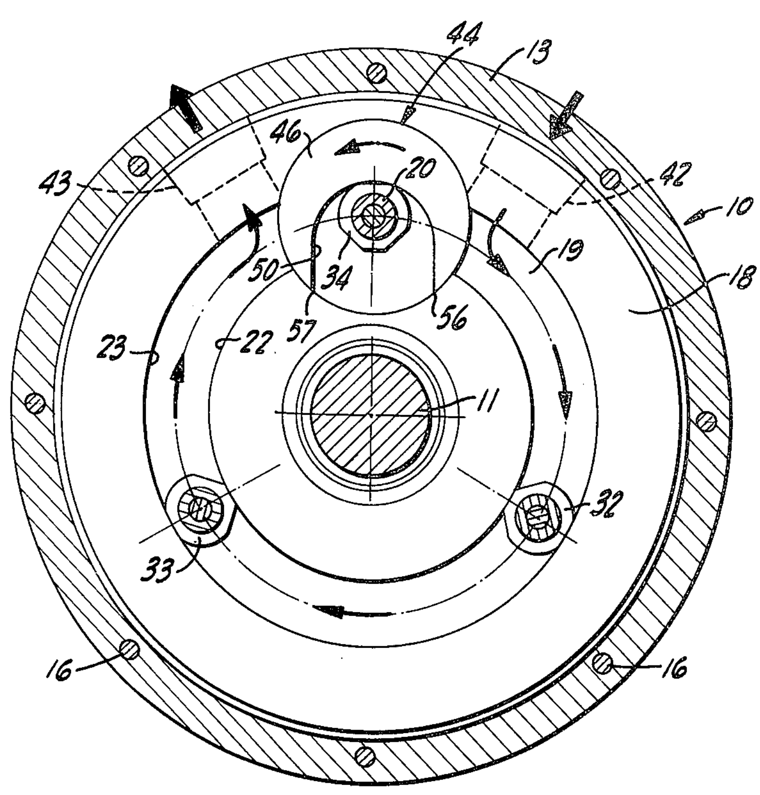

FIG-1

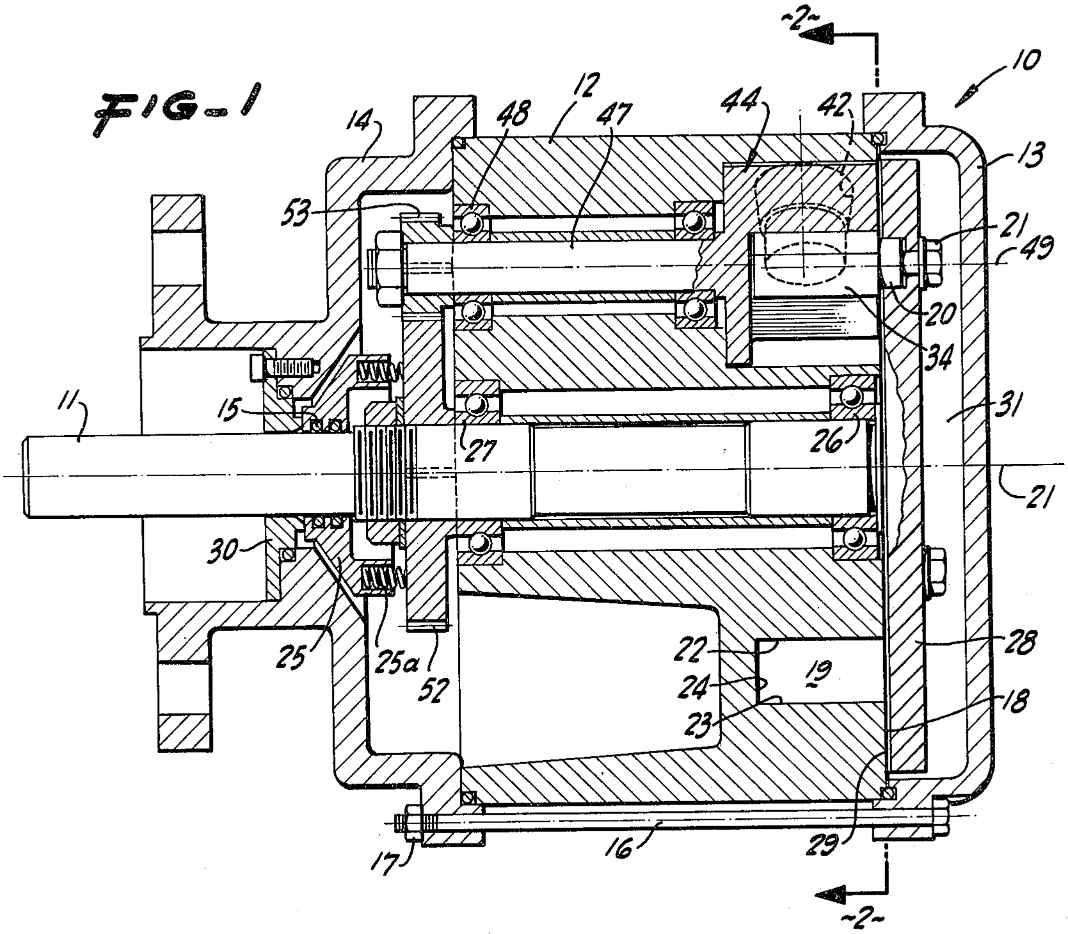
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FIG-2

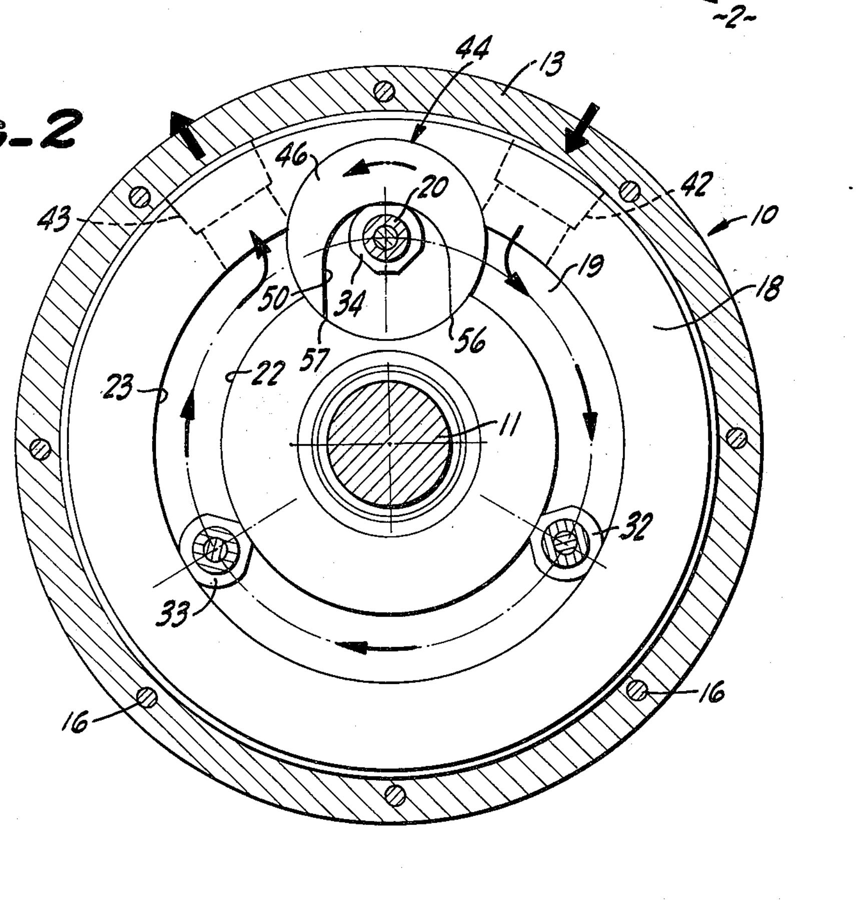
44
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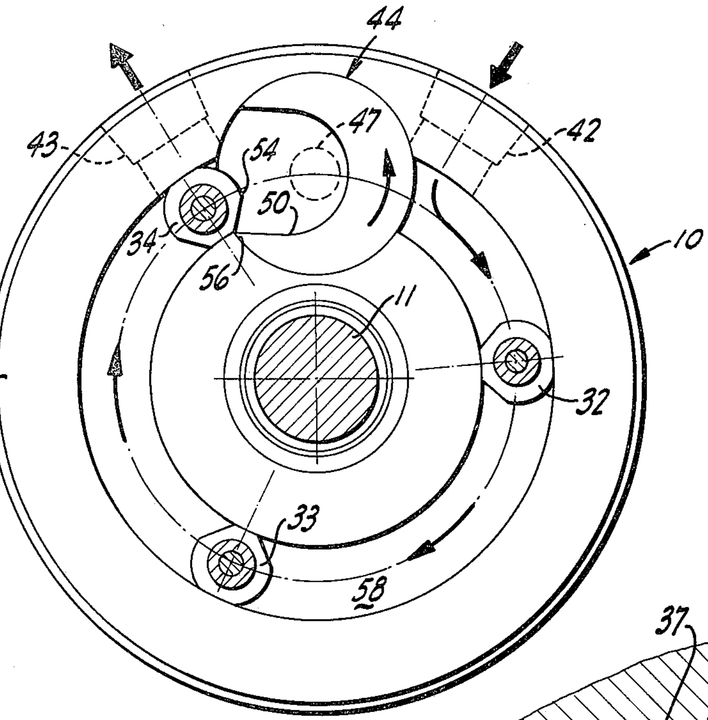
FIG-3



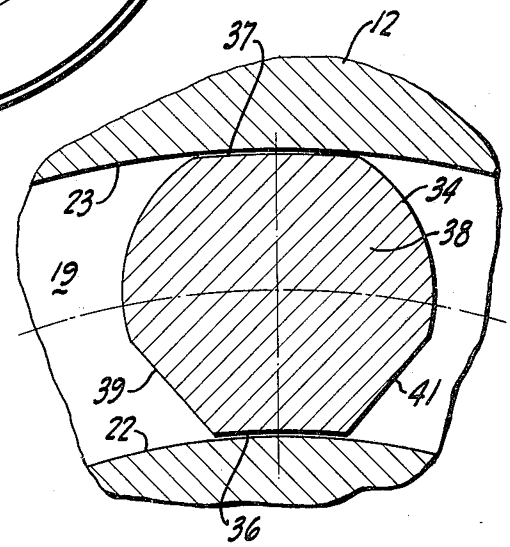
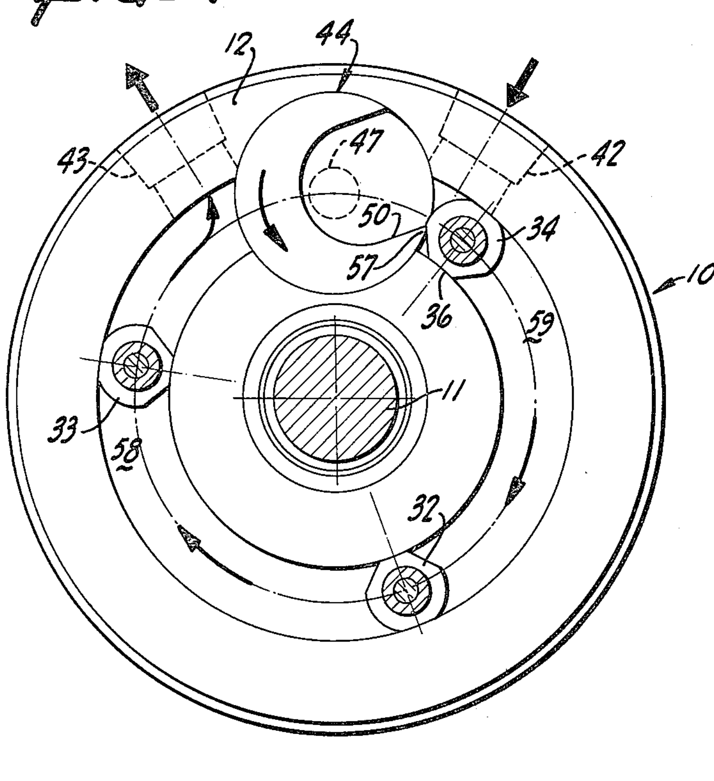


FIG-5

FIG-4



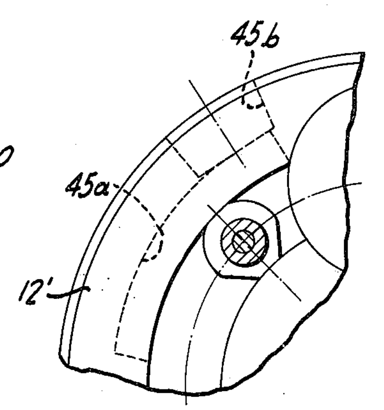


FIG-6

LOW FRICTION, CONTROLLED LEAKAGE ROTARY ENGINE

BACKGROUND OF THE INVENTION

This invention relates in general to rotary engines and in particular relates to rotary engines which operate as either a motor powered from a source of pressurized fluid, such as a gas, or as a pump for developing fluid pressure.

Various types of rotary engines have been suggested or designed and built for operation as either fluid motors or pumps. Positive displacement rotary engines employ the use of pistons, vanes or other elements which move in fluid-tight sealing relationship with a housing or chamber wall for confining the working fluid. Engines of this type possess inherent limitations in their speed and efficiency of operation, complexity and cost of construction and maintenance, high starting friction, and wear on the moving parts, particularly the seal elements. Many of these engines also cannot be dynamically balanced and this further increases the problems of design, engine life, maintenance and operating power requirements. Previous air motors have an effective power limit because large rotors cannot run at the higher speeds.

It is recognized that turbine engines solve many of the foregoing problems in that the turbine engine is dynamically balanced, can run at very high speeds, and has a relatively long life and low maintenance requirements. However, turbine engines possess certain limitations, including greater design and construction costs, such as for fabricating the turbine blades. In addition, turbine engines are inherently "leaky fluid" engines and therefore must be operated at relatively high speeds to attain acceptable efficiencies. The simple turbine engine also is not readily reversible in operation.

OBJECTS AND SUMMARY OF THE INVENTION

It is a general object of the invention to provide a low-friction, controlled leakage rotary engine which is a hybrid form of positive displacement and turbine engine designs.

Another object is to provide a rotary engine of the character described which does not employ sliding surfaces between the piston, rotor and housing so that friction, heat generation, and wear are reduced whereas lubrication of these parts is not required. Lubrication however is not undesirable and in some cases can improve the efficiency of the controlled leakage.

Another object is to provide a rotary engine of the type described which achieves an overlap in the effective pressure stroke of the piston as a result of the size and interrelationship of the blocking valve and inlet port.

Another object is to provide a rotary engine of the character described which employs pistons adapted to rotate through a circular chamber by positive displacement of the working fluid and with dynamically balancing of the moving elements. Fluid leakage between the pistons and chamber is controlled to the extent that fluid-tight seals are not required for sealing the chamber, but at the same time operating efficiency is maintained over a relatively wide speed range.

Another object is to provide a rotary engine of the character described which employs gas or fluid seals between the pistons and chamber, and with the effec-

tiveness of these seals increasing with increased rotor speed.

Another object is to provide a rotary engine of the character described which is relatively simple in design. The engine employs a relatively few number of parts for which close tolerance, and fluid-tight seals, are not required so that costs are reduced. The engine has self-cleaning characteristics to prevent jamming in that any small particles entrained in the working fluid can easily pass through the operating piston and valve passageways.

Another object is to provide a rotary engine of the character described which can be operated over a wide range of speeds but yet which maintains efficiency at low speed operation, which can be rapidly reversed in its direction of rotation, which has a low starting friction, and which can start at any rotor angle.

Another object is to provide a rotary engine of the character described which can be constructed in a wide range of overall sizes, in which high operating efficiency is achieved with greater engine size, and in which a relatively high horsepower-to-weight ratio is obtainable.

The rotary engine of the invention includes a housing formed with a circular chamber in which three pistons are rotated by means of a circular piston plate or rotor. A blocking valve is rotatably mounted across the chamber and the valve is formed with a concaval recess which is shaped to envelope successive pistons as the valve is turned in a 3:1 speed ratio with the rotor. Inlet and outlet ports are provided on opposite sides of the valve for directing a working fluid, such as a pressurized gas, into the chamber. Each of the pistons is formed with a configuration having inner and outer surfaces generally conforming with the radially spaced inner and outer walls of the chamber but with frictionless piston clearance and a controlled leakage of fluid around the piston. The pistons are also formed with generally radially extending flat side walls permitting the pistons to move in non-contacting but close-spaced relationship through the blocking valve while the latter maintains fluid isolation between the two ports. Fluid leakage is also controlled from the chamber through a frictionless clearance between the rotor and housing into a pressure chamber formed by the sealed housing.

Additional objects and features of the invention will appear from the following description in which the preferred embodiment has been set forth in detail in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an axial section view of a rotary engine incorporating the invention;

FIG. 2 is a cross-sectional view taken along the line 2—2 of FIG. 1 illustrating the elements in one operative position;

FIG. 3 is another cross-sectional view similar to FIG. 2 illustrating the elements in another operative position;

FIG. 4 is another cross-sectional view similar to FIG. 2 illustrating the elements in a further operative position;

FIG. 5 is a partial end view to a greatly enlarged scale illustrating the configuration of one of the pistons shown in FIGS. 2–4; and

FIG. 6 is a partial cross-sectional view of another embodiment of the invention which incorporates an enlarged exhaust port.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the drawings FIG. 1 illustrates generally at **10** a rotary engine constructed in accordance with the invention and which is especially adapted for use as a motor driven by pressurized gas. When used as a motor the engine's drive shaft **11** is coupled through a suitable drive train arrangement, not shown, with the particular mechanism which is to be operated. For example, rotary engine **10** can be coupled with a flow control valve in a gas transmission pipeline, with pressurized gas being bled from the pipeline and supplied to the engine as the working fluid. As will become apparent from the disclosure herein, the invention will also find application as a motor with other working media or fluids, and also as a pump in which shaft **11** is powered for pumping a fluid under pressure.

Rotary engine **10** includes a three-element housing assembly which comprises a central cylinder block **12**, a bell cover **13** at one end of the block and a mounting cover **14** at the other end. The three housing elements are secured together to form a pressure sealed chamber by means of a plurality of circumferentially spaced elongate bolts **16** which extend through holes drilled about the peripheries of the two covers, with threaded nuts **17** being mounted on the bolt ends.

The outer end face **18** of cylinder block **12** is machined to form a circular recess or chamber **19** concentric with the longitudinal axis **21** of the block. The chamber is defined by radially spaced side walls **22, 23** and a bottom wall **24.**

Drive shaft **11** is mounted for rotation about axis **21** by means of suitable bearings **26, 27** which are secured within a bore formed through the cylinder block. When used as a motor the drive shaft is coupled through a suitable drive train to the desired end use application, and when used as a pump the drive shaft is powered by a suitable prime mover such as an electric motor. The housing is pressure sealed around the drive shaft by means of a conical member **25,** the inner diameter of which is grooved to seat O-ring seals **15.** A plurality of springs **25***a* are seated in the rim of member **25** to hold the latter in close contact with a stationary bushing **30** which is secured within a circular recess formed in cover **14.** The outer flat end of member **25** thus sealably rotates against the inner shoulder of the bushing **30.** A rotor **28** which provides a circular piston support member or plate is mounted on one end of the drive shaft. This rotor also serves as a flywheel for absorbing force impulses on the rotating elements. The inner face **29** of the rotor extends radially outwardly beyond the outer wall **23** of chamber **19.** The clearance between the inner face of the rotor and the end face **18** of the block is maintained at an optimum dimension so that movement is frictionless but at the same time leakage of fluid from the chamber around the rotor is controlled. The required clearance depends upon the particular design specifications such as surface character and/or finish and type of fluid medium employed, and where engine **10** is utilized as a motor operating from pressurized gas this clearance preferably, but not necessarily, would be in the range of 0.002 to 0.005 inch.

The spacing between bell cover **18** and rotor **28** defines a chamber **31.** The fluid which leaks through the clearance between the rotor and cylinder block escapes into this chamber so that the contained pressure within the housing builds up to the point that it approaches the input pressure to the engine. This serves to reduce the leakage which would otherwise occur so that engine efficiency is maintained, and at the same time the clearance between the block and engine permits relative movement without frictional contact and without the requirement for sealing members.

Three pistons **32, 33** and **34** are mounted on the rotor at equally spaced-apart circumferencial positions with each of the pistons projecting into circular chamber **19.** The circular bases **20** of the piston are seated tightly within recesses that are formed about the rotor, and each piston is secured in position by means of a bolt **21** mounted in an opening extending through the opposite face of the rotor.

FIG. **5** shows the configuration for piston **34** which is typical in construction for the three pistons. The piston is formed with a generally cylindrical cross section of a diameter somewhat greater than the radial distance between the inner and outer side walls **22, 23** of chamber **19.** The inner and outer surfaces **36, 37** of each piston are machined with a curvature conforming generally to the inner and outer chamber walls. The clearances between the piston surfaces and chamber walls are preferably maintained within the range of 0.002 to 0.005 inch, and this same clearance is provided between the flat end face **38** of each piston and the flat bottom wall **24** of the chamber. The clearance between the piston surfaces and the chamber walls permits frictionless relative movement, and also controls leakage of fluid around the pistons in a manner presently to be described. The inner flank sides of each piston are also machined with flat, outwardly diverging surfaces **39, 41.**

An inlet port **42** is formed through one side of the housing to direct inlet fluid into communication with chamber **19,** and an outlet port **43** is formed on the opposite side of the housing to exhaust outlet fluid from the chamber. The inlet port is sized and positioned in relation to the size and phasing of blocking valve **44** so that pressurized fluid communicates into recess **50** as each piston sweeps across the inlet, as shown in FIG. **4.** This permits pressure to build up behind such piston before pressure drops off on the leading piston, with the result that the effective pressure stroke, for a three-piston engine, is approximately 130°, i.e., 10° greater than the 120° spacing between pistons. In other words there is substantially at least a 10° overlap of the pressure strokes for the pistons. This precludes engine stalling and eliminates deadspots in the engine's operation so that it can be started at any rotational angle. The inlet and outlet ports are positioned symetrically on either side of the blocking valve and are designed with the same flow areas so that the operating characteristics of the engine are identical in either direction of rotation.

FIG. **6** shows an embodiment of the invention for use in unidirectional rotation applications in which an elongate outlet port **45a** and tapped opening **45***b* are formed through cylinder block **12'**. Outlet ports **45***a* extends along an arc which is substantially longer in relation to the diameter of the outlet port of the preceding embodiment. Preferably this outlet port extends along an arc of at least one-half, or 60°, of the exhaust stroke, which is equal to the 120° arc between adjacent pistons. This permits outlet gas to exhaust earlier in the exhaust stroke of each piston whereby backpressure is reduced for improved operating efficiency.

A blocking valve **44** is mounted between the two ports to block direct fluid communication between the ports so the fluid is directed in a circular path around the length of chamber **19**. The blocking valve comprises a semi-cylinder **46** having a diameter greater than the radial width of the chamber. The base of the cylinder is carried on a shaft **47** which is mounted on suitable bearings **48** for rotation about an axis **49** which is parallel with the axis **21** of the drive shaft. The base of cylinder **46** adjacent the shaft is circular and is rotatably carried within a circular seat formed about the housing opening through which shaft **47** projects. The opposite end of the cylinder is machined flat for close-spaced relative movement with respect to the inner face **29** of the rotor. A concaval recess **50** is formed in cylinder **46** with a boundary wall sized in width sufficiently larger than the outer diameter of the pistons so as to substantially envelope the pistons as the latter move across the valve location. The portion of the cylinder on the opposite side of the recess is formed with a hollow cavity of a sufficient size to dynamically balance the valve for high speed operation.

Means is provided to drive blocking valve **44** at a 3:1 speed ratio, and in counter rotation, with respect to rotor **28**. Preferably this means includes a large diameter gear **52** secured by suitable means such as keying to drive shaft **11**, together with a small diameter gear **53** having one third the number of teeth of gear **52** and secured by suitable means such as keying to shaft **47**. The two gears are in meshing engagement so that the blocking valve undergoes three revolutions for each revolution of the rotor. The gearing is arranged such that rotation of the blocking valve is in precise timed relationship with movement of successive pistons **32–34** to permit the latter to move across the valve location without contacting the blocking valve and without losing any appreciable inlet pressure across the valve.

As portrayed in the step-wise positional illustrations of FIGS. 2–4 it is the cooperation of the configuration of valve recess **49** with the configuration of the pistons which permits the pistons to be enveloped by the valve without contact while at the same time permitting only a minimum of fluid transfer between the inlet and outlet ports. Thus, as shown in FIG. **3**, assuming that rotor **28** is turning clockwise, the piston has just entered the cross-sectional area of rotation of the blocking valve with recess **50** turned to accept entry of the piston. At the same time leading edge **56** of the recess has moved close to but out of contact with the leading surface of the piston.

Continued movement of the rotor carries piston **34** into the twelve o'clock position of FIG. **2** at which the valve has rotated with its recess facing downwardly. At this position the circular outer surface of the piston is moving in close-spaced but non-contacting relationship with the inner circular portion of the recess. In addition it will be seen that the two recess edges **56, 57** in this position are below the inner wall **22** of chamber **19** for precluding fluid communication between the inlet and outlet ports.

Further movement of the rotor carries piston **34** to the exit position of FIG. **4**. In this position the inner surface **36** of the piston has cleared the valve location and trailing edge **57** of the valve recess is free to move upwardly in close-spaced but non-contacting relationship with the trailing surface of the piston. Continued rotation through a complete cycle carries the next two succeeding pistons **33, 32** through the blocking valve in a similar manner. It will also be realized that the engine is reversible in operation and that the blocking valve will envelop the pistons in a similar manner with counter-clockwise rotor rotation. and clockwise valve rotation.

In operation of the invention, it will be assumed that rotary engine **10** is to be used as a motor driven from a source of pressurized gas. Inlet port **42** is connected through suitable conduit means and flow control valve means, not shown, with the source of gas. Assuming that rotor **28** is initially in the position shown in FIG. **3** the gas is directed under pressure through the inlet port and into the upper righthand portion of chamber **19** where it reacts against each successive pressure-active piston, i.e. the piston which is exposed to the inlet port. In the illustrated rotor position the pressure-active piston is piston **32.** The force of the gas acting on this piston imparts a torque to the rotor for clockwise rotation, and this drives the blocking valve counter-clockwise by means of the gears **52, 53.** The rotor and pistons have no sliding surfaces and are free to move frictionlessly within chamber **19.** The result is that starting friction is very low, lubrication is not required for these elements, heat generation and wear are low, and an overspeed condition will not char the surfaces as could occur with existing air motors. At the same time the closed-spaced clearance between the piston and chamber walls controls leakage around piston **32** into the volume **58** behind second piston **33.** This trapped volume serves as a gas seal by forming a backpressure against the pressurized volume behind piston **32.** The effectiveness of this air seal increases with increased rotor speeds because there is less time for gas to leak from the chambers on each stroke. The closed-spaced clearance between the outer periphery of the rotor and the housing also controls the leakage of gas into chamber **31,** and the housing, and the pressure in the chamber and housing builds up to a value approaching the inlet pressure for effectively precluding further leakage from around the rotor. In addition end thrust on the bearings is reduced, and therefore bearing life is increased, as a result of the equalization of pressure forces in the housing which act on the rotor.

Continued rotation of the rotor carries the elements to the serial positions illustrated in FIGS. 2 and 4 where the blocking valve **44** envelopes the piston **34** in non-contacting relationship for permitting it to pass through the valve location while maintaining fluid isolation between the inlet and outlet ports. As trailing piston **34** sweeps by the inlet port pressure builds up to act on its trailing side while pressure continues to act against next leading piston **32.** This condition exists for approximately 10° of rotation until trailing piston **34** moves across the leading edge of the port to the position of FIG. **4,** thereby providing an effective pressure stroke of 130°. The pressure of the gases isolated in the volume **58** between the pistons **32** and **33** serves as a back pressure to control and limit the degree of fluid leakage around piston **32.** This condition is substantially maintained until piston **33** registers with outlet port **43** for exhausting the trapped gas volume **58.**

It will be realized that rotary engine **10** permits high rotational speeds because the elements, including the rotor and blocking valve, are dynamically balanced and, in addition, the pistons move without frictional contact with the walls of the circular chamber and blocking valve. The frictionless feature results in the engine having a very low starting torque, in comparison to friction contact type engine where starting torques are greater than running torques. The engine can also be quickly reversed in directional rotation, even while operating at high speed, by directing the inlet gas into port **43** with port **42** acting as the exhaust. This reversability feature is important in applications of the invention which involve differential response, e.g., for differential valve closing. The operating characteristics of the engine are identical in either direction of rotation.

While being capable of running at high speed in the manner of a turbine, engine **10** may also be operated throughout a full speed range while maintaining operating efficiency. Thus, good efficiency is obtained at low speeds in the manner of a positive displacement engine as a result of controlling the leakage from around the pistons. At higher rotational speeds efficiency increases as a result of the reduced leakage factor. Operating efficiency is also increased where the engine is scaled upwardly in size while maintaining substantially the same clearance dimensions because the ratio of the piston dimensions to leakage gap becomes greater. In addition the larger size engines of the invention can run at high speeds because of the low friction, dynamically balanced features so that a much higher power can be achieved. For example, doubling the scale of the motor increases the power by a factor of eight.

Rotary engine **10** may be relatively inexpensively constructed as a result of eliminating the requirement for maintaining close tolerances between the piston, chamber and valve elements. Because sliding surfaces are not employed, the surface finish is not limited to any particular finish. In addition, the engine elements may be fabricated from materials selected for their compatibility with the working medium. For example, stainless steel could be used where the working medium is a noxious gas, or a ceramic material could be used for high temperature gases. The invention facilitates the use of materials, which would otherwise be infeasible in conventional rotary engines, such as refactory materials, as a result of the finite clearance between the moving elements as well as gas sealing due to the backpressure effect. These features also result in permitting the engine to be scaled much larger than friction contact type engines and conventional turbine engines.

The provision of maintaining a controlled clearance between the piston, valve and chamber walls prevents the binding or jamming which could otherwise occur with close tolerances, expecially where small foreign particles may become between the elements, or where the elements may change dimension due to wear or temperature variations. The engine has a self-cleaning effect due to the relatively open operating passages because small foreign particles which could otherwise lodge between the elements are carried through by the mainstream fluid flow. Furthermore, no lubrication is required between the pistons, valve and chamber walls because of the elimination of close tolerances and sliding surfaces.

The rotary engine of the invention will find application as a motor design over a wide power size range from fractional horsepower up to large power station size with substantially the same design configuration. Because of the relatively few number of simple parts the engine achieves a relatively low horsepower-to-weight ratio.

In the engine of the present invention driving torque is applied to the pistons without any substantial gas expansion effect of the type that would occur in expanding chamber type engines. This means that the engine operates with substantially continuous full force on the pistons without pressure surges.

The volumetric fuel consumption of this engine is largely a function of speed and inlet pressure and is relatively independent of power. This is in comparison to conventional air motors in which pressure is lost in working against the on-coming vanes moving through the chambers.

The invention also can be advantageously adapted as a compound engine wherein the exhaust from one controlled leakage rotary engine is directed into the inlet of a second similar engine for increasing the overall efficiency. In addition, operating torque variations can be reduced by coupling two or more of the rotary engines for out-of-phase operation on a common drive shaft.

While the foregoing embodiments are at present considered to be preferred it is understood that numerous variations and modifications may be made therein by those skilled in the art and it is intended to cover in the appended claims all such variations and modifications as fall within the true spirit and scope of the invention.

I claim:

1. A rotary engine comprising the combination of a housing formed with a circular chamber concentric with a first longitudinal axis, means forming inlet and outlet ports in the housing for directing a working fluid into and from the chamber, a piston support member mounted within the housing for rotation about the first axis and with one side of the chamber being exposed to the support member, three circumferentially spaced-apart pistons carried by the support member, each piston projecting longitudinally from the support member into the chamber and being spaced from the chamber walls with a frictionless clearance through which fluid is directed to the volume ahead of the pressure-active piston which is exposed to the inlet port whereby the pressure differential across such piston is insubstantial for minimizing further fluid leakage past said frictionless clearance, a blocking valve positioned across the chamber between said inlet and outlet ports, said valve being mounted for rotation about a second axis parallel with said first axis, said valve being formed with a recess of a size sufficient to substantially envelope the pistons, and means for rotating the valve about the second axis in timed relationship with rotation of the support member whereby the pistons carried thereby move through the recess in the valve while the latter blocks substantial communication of fluid therethrough between the inlet and outlet ports.

2. A rotary engine as in claim **1** in which said working fluid is a gas, and the pressure which is maintained in said volume forms a gas seal to control said leakage, said gas seal having an efficiency which increases with increased rotary speed of the support member.

3. A rotary engine as in claim **1** in which said working fluid is a gas, and in which said clearance is in the range of substantially 0.002 to 0.005 inches.

4. A rotary engine as in claim **1** in which the housing includes a cylinder block, the outer circular portion of said piston support member is spaced from the cylinder block with a frictionless clearance, and said housing forms a closed volume about said rotor to receive fluid leaking through said clearance and to confine and maintain such fluid under pressure to limit further leakage through said clearance.

5. A rotary engine as in claim **1** in which said circular chamber includes radially spaced-apart inner and outer circular walls, and said pistons are formed with radially spaced-apart inner and outer surface portions each having a radius commensurate generally with the respective radii of the inner and outer chamber walls, said surface portions of the pistons being spaced from the respective inner and outer chamber walls with a frictionless clearance which controls the leakage of fluid therebetween.

6. A rotary engine as in claim **1** in which said piston support member comprises a circular rotor having a substantial moment of inertia to function as a flywheel for absorbing force pulses acting on the rotor.

7. A rotary engine as in claim **1** for use as a fluid pump in which said inlet port is connected to a source of fluid, and drive means is provided to rotate the support member about the first axis whereby fluid is inducted through the inlet port and exhausted under pressure through the outlet port.

8. A rotary engine as in claim **1** in which said inlet port is positioned for communication with the recess of the blocking valve as each successive piston passes the inlet port whereby inlet pressure begins to act against the trailing side of such piston while pressure continues to act against the next leading piston to achieve an overlap of the pressure stroke for each piston.

9. A rotary engine as in claim **8** in which movement of each successive piston past the inlet port builds up pressure on the trailing piston at a rate comparable to the reduction in pressure on the next leading piston.

10. A rotary engine as in claim **9** in which said trailing piston moves through an arc of substantially at least 10° across the inlet port while said build up of pressure is occurring whereby a force overlap of substantially at least 10° is created in the pressure stroke of each piston.

11. A rotary engine as in claim **1** for use in unidirectional engine rotation application in which said outlet port is elongate in the direction of piston movement for exhausting fluid and reducing backpressure in the exhaust stroke of each piston.

12. A rotary engine as in claim **11** in which said outlet port extends along an arc of substantially at least one-half of the exhaust stroke.

13. A rotary engine comprising the combination of a housing formed with a circular chamber concentric with a first longitudinal axis, said chamber having radially spaced inner and outer walls, means forming a cylindrical blocking valve positioned across the chamber and being mounted for rotation about a second axis parallel with said first axis, means forming inlet and outlet ports in the housing on opposite sides of the blocking valve for directing a working fluid into and from the chamber, a rotor mounted within the housing for rotation about the first axis with one side of the chamber being exposed to the rotor, three circumferentially spaced-apart pistons carried by the rotor and which project into the chamber, said pistons being formed with radially spaced-apart inner and outer surface portions each having a radius commensurate generally with the respective radii of the inner and outer walls of the chamber, said surface portions of the pistons being spaaced from the respective inner and outer chamber walls with a frictionless clearance which directs leakage of fluid therebetween into the chamber defined between adjacent pistons whereby the pressure differential across the pressure—active piston is insubstantial for minimizing further fluid leakage past said frictionless clearance, said blocking valve being formed with a recess having a concave boundary wall which opens outwardly through one side of the valve to substantially envelop the pistons, and drive train means for turning the blocking valve in a 3:1 speed ratio with respect to rotation of the rotor whereby the pistons carried thereby move through the recess in the valve while the latter substantially blocks direct communication of fluid between the inlet and outlet ports.

14. A rotary engine for use as a gas engine comprising the combination of a housing formed with a circular chamber having chamber walls, a rotor mounted for rotation within the housing, a plurality of at least three of circumferentially spaced-apart pistons mounted on the rotor for movement about a circular path within the chamber, each of said pistons having radially spaced inner and outer surfaces with curvatures conforming generally to the chamber walls and being spaced therefrom a clearance distance which permits controlled leakage of gas therebetween, each piston further being formed with a flat end face which is spaced from the bottom wall of the chamber another clearance distance which permits controlled leakage of gas therebetween, means forming inlet and outlet ports in the housing for directing a gas into and from the chamber, blocking valve means positioned in the chamber between the inlet and outlet ports for blocking gas flow therebetween across the valve while permitting movement of the pistons across the position of the valve, means for rotating the valve in timed relationship with rotation of the rotor and pistons responsive to gas under pressure being directed into the inlet port, with said pressurized gas imparting a torque force on successive pressure-active pistons which are exposed to the inlet port within the chamber simultaneous with leakage of gas through said clearances to create a pressure in the volume of the chamber on the opposite side of said pressure-active piston whereby the pressure differential across the pressure-active piston is insubstantial so that further leakage past such piston is minimized.

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