Dec. 5, 1967 T. W. KENNEDY 3,356,291

ROTARY PISTON MACHINE

Filed Oct. 6, 1965

FIG. 1

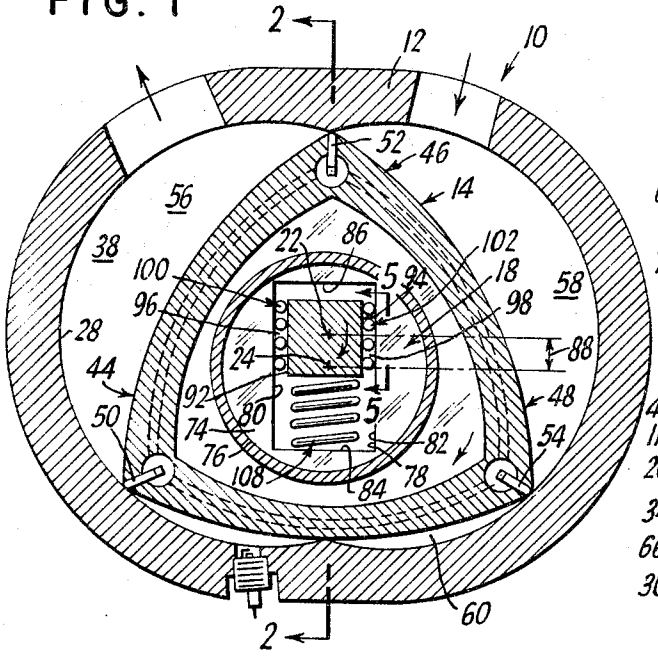


FIG. 2

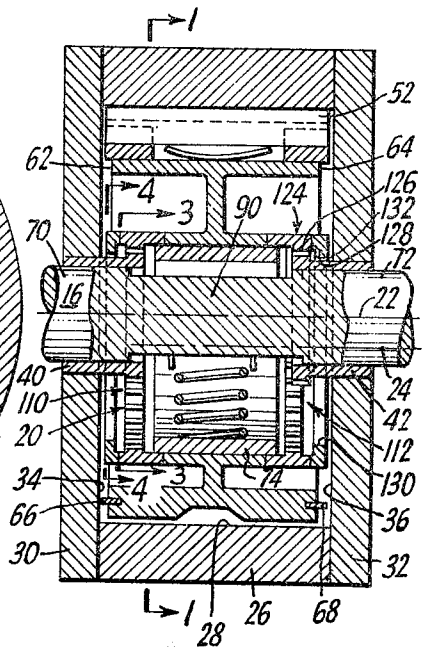


FIG. 3

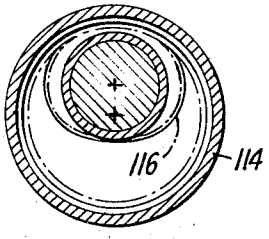


FIG. 5

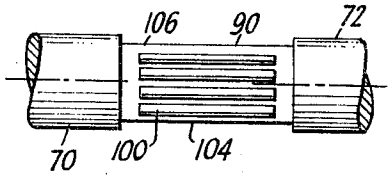
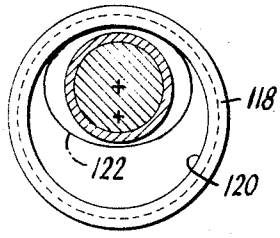


FIG. 4



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ROTARY PISTON MACHINE

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ABSTRACT OF THE DISCLOSURE

A rotary machine for use as a combustion engine, pump or motor comprising: an outer body with a longitudinal axis having a peripheral wall and a pair of axially-spaced end walls forming a cavity therebetween; an inner body disposed in said cavity forming a plurality of peripherally-spaced, variable-volume chambers therebetween and having an axis arranged parallel to said outer body axis; gear means engaging said inner body and said outer body for rotating said inner body about its axis; and shaft means mounted on said outer body coaxially therewith with a variable-offset eccentric portion on which said inner body is journaled coaxially therewith for revolving said inner body about said outer body axis and for varying the offset distance between said inner body axis and said outer body axis in a selective manner.

The present invention relates to a rotary piston machine and particularly to a rotary piston machine having a variable-offset shaft eccentric.

A prior-art rotary piston machine for use as a pump, a motor or a combustion engine, is described in U.S. Patents Nos. 724,994, 1,617,863, 1,636,486, 2,988,008 and 2,988,065. Said prior-art rotary piston machine includes an outer body having a cavity with an axis, a shaft extending through said outer body coaxially therewith, said shaft having an eccentric portion disposed in said cavity with an axis parallel to said shaft axis and offset at a fixed distance therefrom, and an inner body disposed in said cavity journaled on said eccentric coaxially therewith for planetary rotation relative to said outer body and for forming variable-volume chambers therebetween. Said outer body has an inner surface and said inner body has an outer surface facing said inner surface. One of said surfaces has a controlling profile of one or more lobes, the profile being either an epitrochoidal profile or an hypotrochoidal profile.

One problem with said prior-art rotary piston machine is that said controlling profile, which is either an epitrochoidal shape or hypotrochoidal shape, limits the chamber displacement ratio and the engine compression ratio, as fully explained in the aforementioned U.S. Patent No. 2,988,065.

In accordance with one embodiment of the present invention, the chamber displacement ratio and compression ratio can be improved substantially by using a varying-offset gear means and a varying-offset eccentric means, which generate a novel profile that is not as limiting as said epitrochoidal profile and said hypotrochoidal profile.

Accordingly, it is one object of the invention to provide a rotary machine having an inner body supported within an outer body for rotation relative thereto about an axis parallel to the axis of said outer body with a varying offset between the outer body axis and the inner body axis, the machine being a type in which either the inner body or the outer body rotates and the opposite body is stationary, or a type in which both the inner and the outer body rotate in the same direction.

It is another object of the invention to provide the aforementioned rotary machine according to the aforementioned object, which can also be used as an internal combustion engine.

It is still another object of the invention to provide a combustion engine according to the aforementioned objects having an outer body with an inner surface having a profile that is described by a line that is generated by a point on the inner surface of a circle rolling on the outer surface of a modified ellipse.

To the fulfillment of these and other objects, the invention provides a rotary machine comprising an outer body, an inner body, a gear means and a shaft with a variable-offset eccentric portion. Said outer body has a peripheral wall with a longitudinal axis and a pair of axially-spaced end walls forming a cavity therebetween. Said inner body is disposed in said cavity forming a plurality of peripherally-spaced, variable-volume chambers therebetween and having an axis arranged parallel to said outer body axis. Said gear means engages said inner body and said outer body for rotating said inner body about its own axis. Said shaft is mounted on said outer body coaxially therewith. Said eccentric portion supports said inner body for revolving of said inner body about said outer body axis and for varying the offset distance between said inner body axis and said outer body axis in a selective manner.

Other objects of the invention will become apparent upon reading the annexed description. The following drawings, wherein like parts are designated by like numerals in the several views, include:

FIG. 1 is a sectional view of a rotary machine embodying features of the present invention;

FIG. 2 is a sectional view taken along the line 2—2 of FIG. 1;

FIG. 3 is a sectional view taken along the line 3—3 of FIG. 2;

FIG. 4 is a sectional view taken along the line 4—4 of FIG. 2; and

FIG. 5 is a sectional view taken along the line 5—5 of FIG. 1.

Referring to FIG. 1, one embodiment of the present invention is a rotary machine or combustion engine **10**. Engine **10** includes an outer body **12**, an inner body **14** enclosed by outer body **12**, a shaft **16** extending through outer body **12** with an eccentric portion or crank arm **18** on which inner body **14** is journaled, and a gear means **20** for rotation of inner body **14** relative to outer body **12**.

Outer body **12** and shaft **16** are coaxial along a common outer body axis **22**. Inner body **14** and eccentric **18** are coaxial along a common axis **24**.

Outer body **12** has a peripheral wall **26** with a radially-inner surface **28** and a pair of end walls **30**, **32** with respective axially-inner faces **34**, **36** which together form a cavity **38**. End walls **30**, **32** have respective wall bearings **40**, **42**, which are coaxial with each other along axis **22**.

Inner body **14** has three apex portions **44**, **46**, **48** with respective apex seals **50**, **52**, **54**, which engage radially-inner surface **28** and which form three working chambers **56**, **58**, **60** therebetween. Inner body **14** has axially-outer sides **62**, **64**, which respectively face inner faces **34**, **36**. Outer sides **62**, **64** have respective end seals **66**, **68**, which engage inner faces **34**, **36** for gas and oil sealing.

Shaft **16** has axially-spaced portions **70**, **72**, which are respectively journaled in wall bearings **40**, **42**. Shaft **16** is coaxial with outer body **12** along axis **22**.

Eccentric **18** has a peripheral wall **74** with a circular radially-outer surface **76**, and has a rectangularly-shaped opening **78**, which extends therethrough in an axial direction. Opening **78** has opposite lengthwise radially-inner bearing surfaces **80**, **82** and has opposite short side radially-inner surfaces **84**, **86**. Eccentric **18** is coaxial with

inner body **14** along axis **24**, which is parallel to shaft axis **22**. Axis **24** is separated from axis **22** by a variable offset or distance **88**, which varies in a selective manner with each revolution of eccentric **18** and shaft **16**. Eccentric **18** also has an intermediate shaft portion **90** with a square cross-section, which is fixedly connected at its ends to shaft portions **70**, **72** coaxially therewith.

Intermediate shaft portion **90** has a pair of radially-outer bearing faces **92**, **94**, which respectively face surfaces **80**, **82** and which form gaps **96**, **98** therebetween. Gaps **96**, **98** contain respective anti-friction means **100**, **102**, such as roller-type bearings. Intermediate shaft portion **90** also has a pair of radially-outer faces **104**, **106**, which face toward respective surfaces **84**, **86**. Eccentric **18** also has a compression spring means **108**, such as a compression coil spring, which is disposed between surface **84** and face **104** urging said parts apart and tending to increase the size of offset **88**. With this construction, eccentric **18** has a variable-offset type of eccentricity.

Gear means **20** includes a pair of axially-spaced gear units **110**, **112**. Gear unit **110** is identical to gear unit **112** and is described hereafter in detail.

Gear unit **110** includes a large circular gear **114** which has internal teeth and which is fixedly connected to inner body **12** coaxially therewith along axis **24**. Gear unit **110** also has a smaller ellipse gear, which has external teeth and which preferably has a modified-elliptical outer profile. Ellipse gear **116** meshes with circular gear **114**. Ellipse gear **116** has two-thirds the number of gear teeth as circular gear **114**. Outer body **14** is preferably stationary, and shaft **16**, eccentric **18** and inner body **14** rotate relative thereto in the same clockwise direction. Shaft **16** and eccentric **18** have a rotary speed, which is three times greater than the rotary speed of inner body **14**.

With such construction, embodiment **10** has a novel profile, which is the profile of inner surface **28**, which is the travel path of the tips of apex seals **50**, **52**, **54**, which has definite non-epitrochoidal mathematical characteristics, and which is generated by the rolling of circular gear **114** on ellipse gear **116**. Thus, engine **10** has a relatively larger intake chamber and relatively smaller compression chamber with an improved displacement ratio and an improved compression ratio. Moreover, sharp changes in the curvature of said profile of surface **28** can be substantially avoided thereby improving gas sealing.

Circular gear **114** preferably has an adjacent ring-shaped shoulder **118** with a circular radially-inner bearing surface **120**. Ellipse gear **116** has a corresponding adjacent elliptical radially-outer bearing surface **122**, which is in rolling contact with surface **120**. With such construction, eccentric shear loads, which are directed in a radially-inward direction, pass through shoulder **118** and surfaces **120**, **122** from inner body **14** to outer body **12** thereby minimizing shear load on gears **114**, **116**. However, tangential torque loads pass directly through gears **114**, **116** from inner body **14** to outer body **12** for torquing shaft **16**.

Gear unit **112** also has an identical internal circular gear **124** and an ellipse gear **126**. Gear **124** has an identical shoulder **128** with a radially-inner bearing surface **130**, and gear **126** has an identical radially-outer bearing surface **132**. With such construction, shear loads acting on inner body **14** are balanced and resisted by equal reactions from gear units **110**, **112**.

In summary, this invention provides a rotary machine comprising an outer body and an inner body disposed therein for rotation relative thereto, in which either the inner body or the outer body can be the rotating body, or in which both the inner body and outer body can be rotating bodies, in which said machine can be used as an internal combustion engine, and in which the outer body of the machine has an inner surface with a novel profile of the type generated by a point on the surface of a circle rolling on the surface of a modified ellipse.

While the present invention has been described in a preferred embodiment, it will be obvious to those skilled in the art that various modifications can be made therein within the scope of the invention. It is intended that the appended claims cover all such modifications.

What is claimed is:

1. A rotary machine for use as a combustion engine, pump or motor comprising:

an outer body with a longitudinal axis having a peripheral wall and a pair of axially-spaced end walls forming a cavity therebetween;

an inner body disposed in said cavity forming a plurality of peripherally-spaced, variable-volume chambers therebetween and having an axis arranged parallel to said outer body axis;

gear means engaging said inner body and said outer body for rotating said inner body about its axis; and

shaft means mounted on said outer body coaxially therewith a variable-offset eccentric portion on which said inner body is journaled coaxially therewith for revolving said inner body about said outer body axis and for varying the offset distance between said inner body axis and said outer body axis and in which said outer body peripheral wall has a radially inner surface having a profile which is substantially a modified epitrochoidal curve, said curve being defined as the locus of a point in the plane of a circle which rolls without slipping on an ellipse in such a way that the planes of the circle and ellipse meet under constant angle.

2. A rotary machine for use as a combustion engine, pump or motor comprising; an outer body with a longitudinal axis having a peripheral wall and a pair of axially-spaced end walls forming a cavity therebetween; an inner body disposed in said cavity forming a plurality of peripherally-spaced, variable-volume chambers therebetween and having an axis arranged parallel to said outer body axis; gear means engaging said inner body and said outer body for rotating said inner body about its axis; and shaft means mounted on said outer body coaxially therewith with a variable-offset eccentric portion on which said inner body is journaled coaxially therewith for revolving said inner body about said outer body axis and for varying the offset distance between said inner body axis and said outer body axis in a selective manner, in which said gear means includes at least one gear unit comprising:

an internal gear with a circular shape fixedly connecting to said inner body coaxially therewith; and

an external gear with a modified-elliptical shape fixedly connecting to said outer body coaxially therewith

for varying the offset between said inner body and said outer body and for rotating said inner body relative to said outer body.

3. A rotary machine for use as a combustion engine, pump or motor comprising: an outer body with a longitudinal axis having a peripheral wall and a pair of axially-spaced end walls forming a cavity therebetween; an inner body disposed in said cavity forming a purality of peripherally-spaced, variable-volume chambers therebetween and having an axis arranged parallel to said outer body axis; gear means engaging said inner body and said outer body for rotating said inner body about its axis; and shaft means mounted on said outer body coaxially therewith with a variable-offset eccentric portion on which said inner body is journaled coaxially therewith for revolving said inner body about said outer body axis and for varying the offset distance between said inner body axis and said outer body axis in a selective manner, in which:

said inner body has a shoulder portion disposed adjacent to said gear means with a radially-inner bearing surface of circular shape; and

said outer body has a portion disposed adjacent to said gear means with a radially-outer bearing surface of modified-elliptical shape and in rolling contact with said radially-inner bearing surface for minimizing loading on said gear means.

4. A rotary machine comprising:
an outer body having a peripheral wall with a longitudinal axis and a pair of axially-spaced end walls forming a cavity therebetween;
a shaft coaxial with said outer body along said outer body axis mounted in said end walls and extending through said cavity for rotation relative to said outer body;
a shaft eccentric portion mounted on said shaft for rotation together therewith relative to said outer body with an eccentric axis disposed parallel to said outer body axis and separated therefrom by an offset distance, said eccentric having means substantially varying said offset distance in a selective manner with each revolution of said eccentric axis about said outer body axis;
an inner body journaled on said eccentric portion coaxially therewith and disposed in said cavity for rotation about said outer body axis relative to said outer body and forming a plurality of peripherally-spaced, variable-volume chambers therebetween; and
gear means interconnecting said inner body and said outer body for rotation of said inner body about said eccentric axis relative to said eccentric at a fixed speed ratio, said gear means comprising a circular gear, and an ellipitical gear which meshes with said circular gear, and in which one of said gears is fixedly connected to the inner body and the other said gear is fixedly connected to the outer body.

5. A rotary engine comprising:
an outer body with an axis having a peripheral wall with a radially-inner surface and a pair of axially-spaced end walls with axially-inner faces forming a cavity, said end walls having wall bearings;
an inner body with an axis disposed in said cavity and having a plurality of apex portions with respective apex seals engaging said radially-inner surface forming a plurality of working chambers therebetween and having axially-outer sides with respective end seals engaging said end faces;
a shaft having axially-spaced portions journaled in said wall bearings;
an eccentric portion mounted on said shaft having a

peripheral wall with a circular radially-outer surface and having an opening extending therethrough with lengthwise bearing surfaces and widthwise bearing surfaces, said eccentric being journaled in said inner body coaxially therewith and having a variable offset distance from said shaft axis, said offset varying a selective manner with each revolution of said eccentric and said shaft;
said eccentric having an intermediate shaft portion integral with said shaft end portions and having a square cross-section and being journaled in said opening, said intermediate shaft having a pair of radially-outer bearing faces facing said inner bearing surfaces with a pair of anti-friction means disposed therebetween and having a compressive spring means disposed in said opening adjacent said intermediate shaft portion;
said gear means including a pair of gear units with each gear unit having a circular gear with internal teeth and a smaller ellipse gear with external teeth, said circular gear being fixedly connected to said inner body and said ellipse gear being fixedly connected to said outer body; and
said circular gear having a shoulder with a circular radially-inner bearing surface and said ellipse gear having a corresponding adjacent elliptical radially-outer bearing surface in rolling contact with said inner bearing surface.

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