



US010570739B2

(12) **United States Patent**
Grisar

(10) **Patent No.:** **US 10,570,739 B2**
(45) **Date of Patent:** **Feb. 25, 2020**

(54) **CIRCLE ELLIPSE ENGINE**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **15/613,237**

(22) Filed: **Jun. 4, 2017**

(65) **Prior Publication Data**

US 2018/0347363 A1 Dec. 6, 2018

(51) **Int. Cl.**

F01C 21/08 (2006.01)
F02B 55/10 (2006.01)
F02B 55/04 (2006.01)
F02B 55/14 (2006.01)
F02B 55/16 (2006.01)
F02B 53/10 (2006.01)
F01C 1/344 (2006.01)
F01C 21/04 (2006.01)
F01C 21/06 (2006.01)
F01C 21/10 (2006.01)
F01M 11/02 (2006.01)
F01M 11/00 (2006.01)

(52) **U.S. Cl.**

CPC **F01C 21/0836** (2013.01); **F01C 1/3446** (2013.01); **F01M 11/0004** (2013.01); **F01M 11/02** (2013.01); **F02B 55/04** (2013.01); **F02B 55/10** (2013.01); **F01C 21/04** (2013.01); **F01C 21/06** (2013.01); **F01C 21/108** (2013.01); **F02B 53/10** (2013.01); **F02B 55/14** (2013.01); **F02B 55/16** (2013.01)

(58) **Field of Classification Search**

CPC **F01C 21/0836**; **F01C 21/0809**; **F01C**

1/3446; **F01C 1/3448**; **F01M 11/02**; **F02B 53/00**; **F02B 53/04**; **F02B 53/10**; **F02B 55/04**; **F02B 55/10**; **F02B 55/14**; **F02B 55/16**
USPC **123/205**, **229**, **241**, **243**; **418/124**, **173**, **418/217**, **219**, **231–232**, **261**, **264**
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

1,527,685 A * 2/1925 Huwiler **F04C 2/3446**
418/261
1,686,767 A * 10/1928 Saxon **F02B 53/00**
123/243
2,345,561 A * 4/1944 Allen, Jr. **F01C 1/3446**
418/264

(Continued)

FOREIGN PATENT DOCUMENTS

EP 0548416 A1 * 6/1993 **F01C 1/3448**
EP 1617040 A2 * 1/2006 **F01C 1/3448**

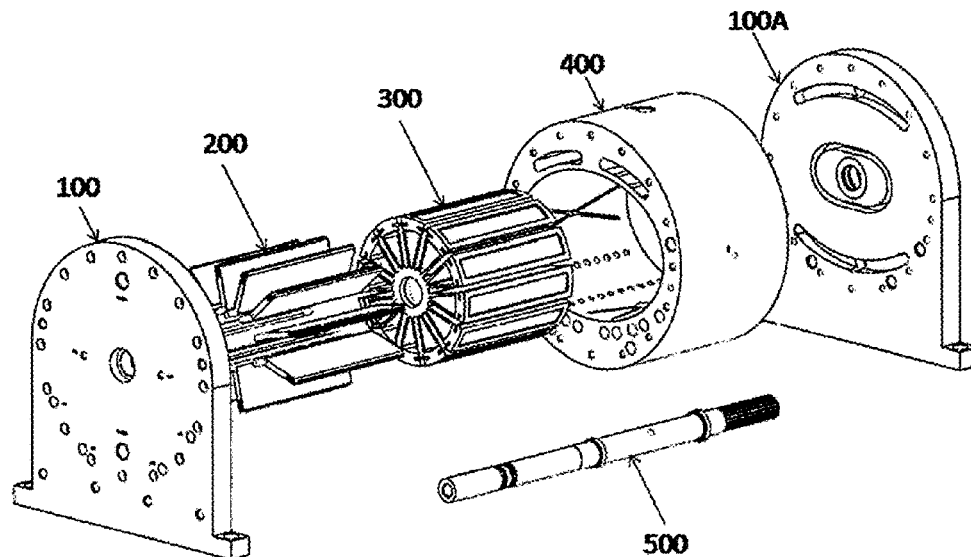
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Primary Examiner — Thai Ba Trieu

(57) **ABSTRACT**

A circle-ellipse engine includes a stationary circular outer housing having a fixed elliptical inner cam surface, and a separate internal round rotor partitioned into equal segments that are populated by identical movable radial vanes. During rotation, the end of the vanes are positioned a precise, constant distance from the elliptical inner cam surface of the housing. During rotation, a variable height cavity is created representing the difference between the major and minor axes of the elliptical inner cam surface and the rotor face. During each rotation, aspirated air is continuously drawn into combustion chambers, compressed, mixed with fuel, ignited, and exhaust gas products are expelled.

3 Claims, 9 Drawing Sheets



(56)

References Cited

U.S. PATENT DOCUMENTS

2,590,729 A * 3/1952 Scognamiglio F04C 18/352
418/173
2,988,065 A * 6/1961 Wankel F02B 53/04
123/242
3,468,260 A * 9/1969 Belden F04C 2/3448
418/152
3,551,080 A * 12/1970 Feller F01C 19/02
418/124
3,769,945 A * 11/1973 Kahre F01C 1/3568
418/217
3,799,710 A * 3/1974 Jacobs F01C 1/3448
418/147
3,865,521 A * 2/1975 Upchurch F01C 19/08
418/121
3,873,253 A * 3/1975 Eickmann F01C 21/0809
418/261
4,004,556 A * 1/1977 Pfeiffer F02B 53/00
123/243
4,028,028 A * 6/1977 Fuchs, Jr. F01C 1/3448
418/219
4,325,394 A * 4/1982 Reams G03F 7/30
134/141
4,401,070 A * 8/1983 McCann F01C 1/3448
123/229
4,474,105 A * 10/1984 Eicher F15B 15/12
92/122
4,573,892 A * 3/1986 DuFrene B62D 13/00
418/219
4,575,324 A * 3/1986 Sommer F01C 21/0809
418/217

4,667,468 A * 5/1987 Hansen F01C 1/3441
123/248
4,799,867 A * 1/1989 Sakamaki F01C 21/0836
418/1
5,429,084 A * 7/1995 Cherry F01C 1/3448
123/243
5,509,793 A * 4/1996 Cherry F01C 1/3448
123/243
5,524,587 A * 6/1996 Mallen F01C 1/3446
123/202
5,551,853 A * 9/1996 Cherry F01C 1/3448
418/137
5,634,783 A * 6/1997 Beal F01C 21/0836
418/264
6,776,136 B1 * 8/2004 Kazempour F01C 1/3446
123/243
7,707,987 B2 * 5/2010 Guthrie F01C 1/3446
123/243
7,896,630 B2 * 3/2011 Grisar F01C 1/3448
418/261

FOREIGN PATENT DOCUMENTS

GB 1110162 A * 4/1968 F01C 19/10
GB 1430196 A * 3/1976 F15B 15/103
GB 2419382 A * 4/2006 F01C 1/3441
JP 55098689 A * 7/1980 F01C 21/0081
JP 02019601 A * 1/1990
WO WO-8503736 A1 * 8/1985 F01C 21/0881
WO WO-0133082 A1 * 5/2001 F01C 1/3446
WO WO-2006018848 A2 * 2/2006 F01C 1/3441

* cited by examiner

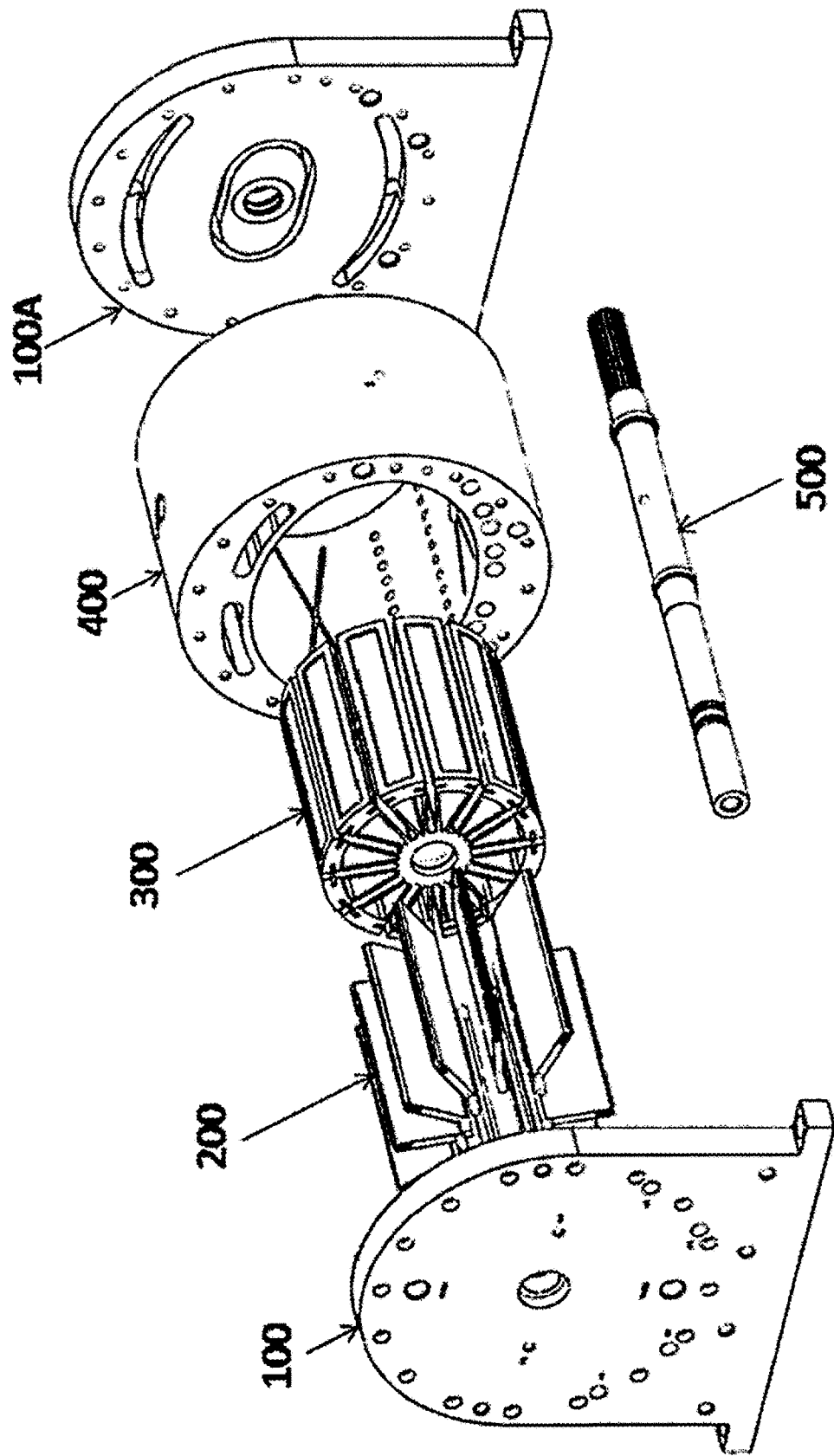
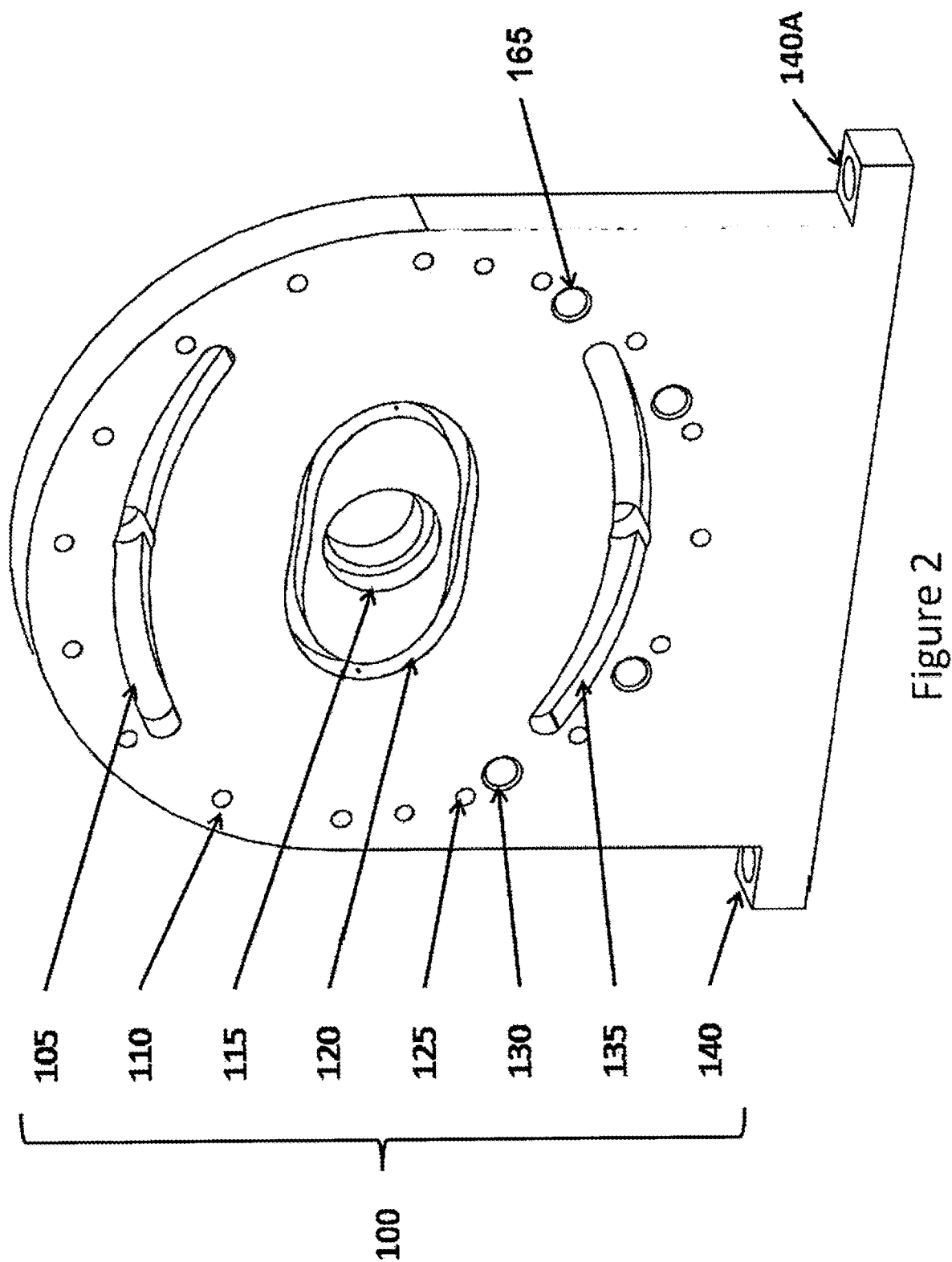
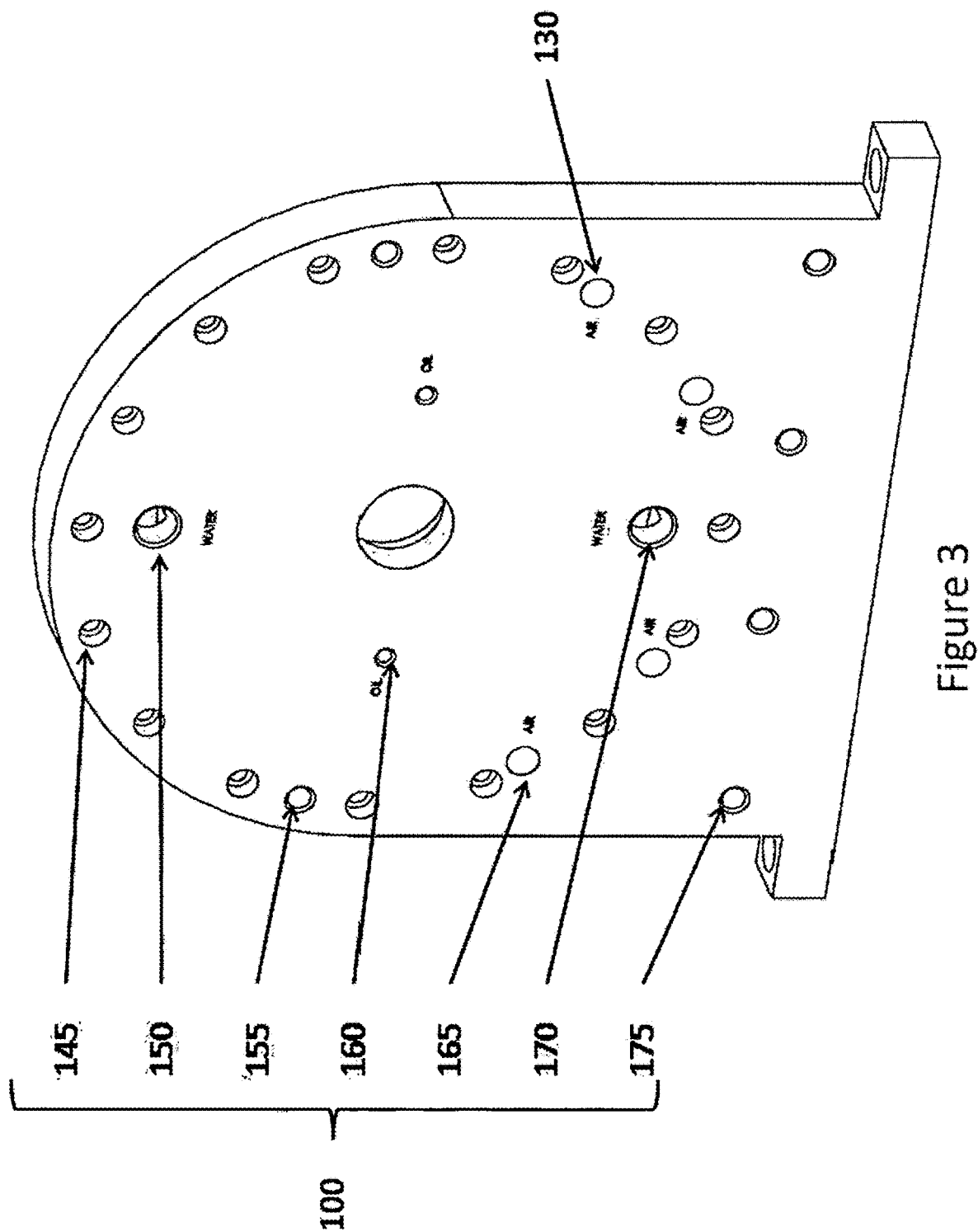


Figure 1





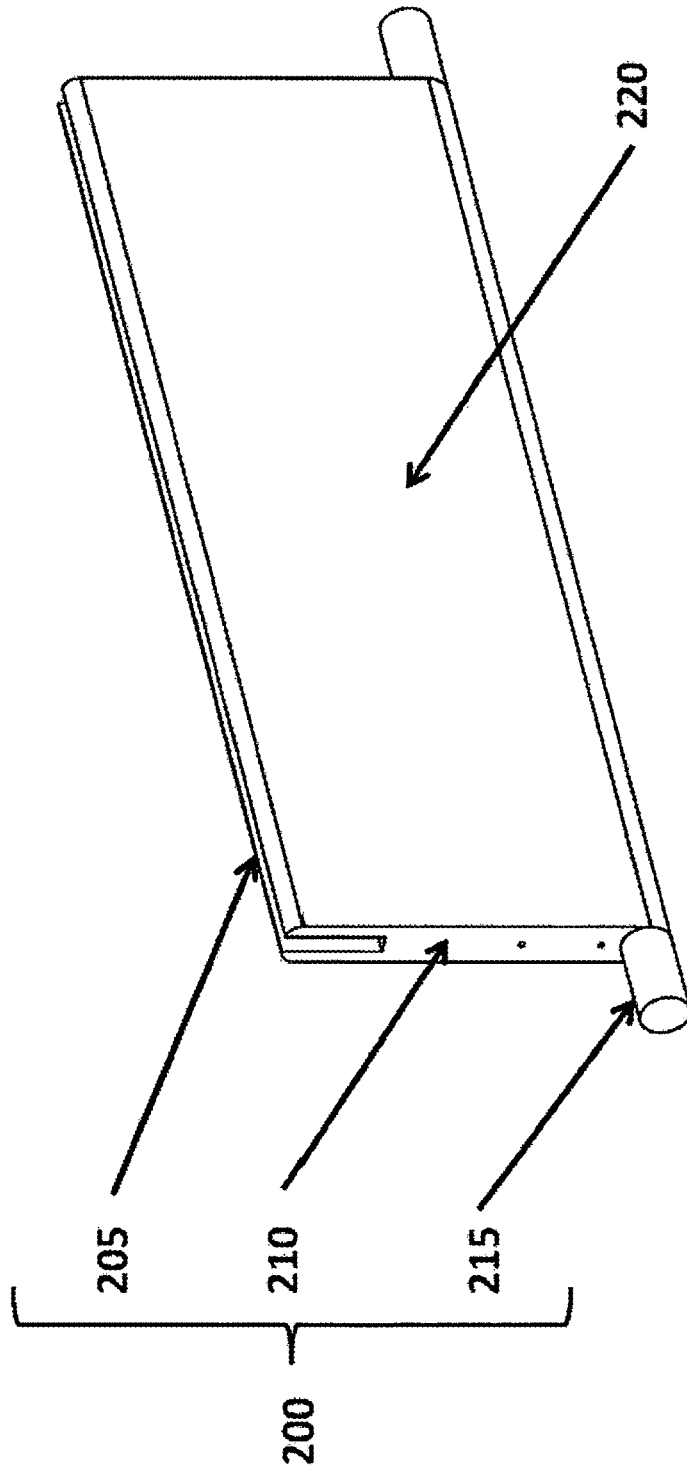


Figure 4

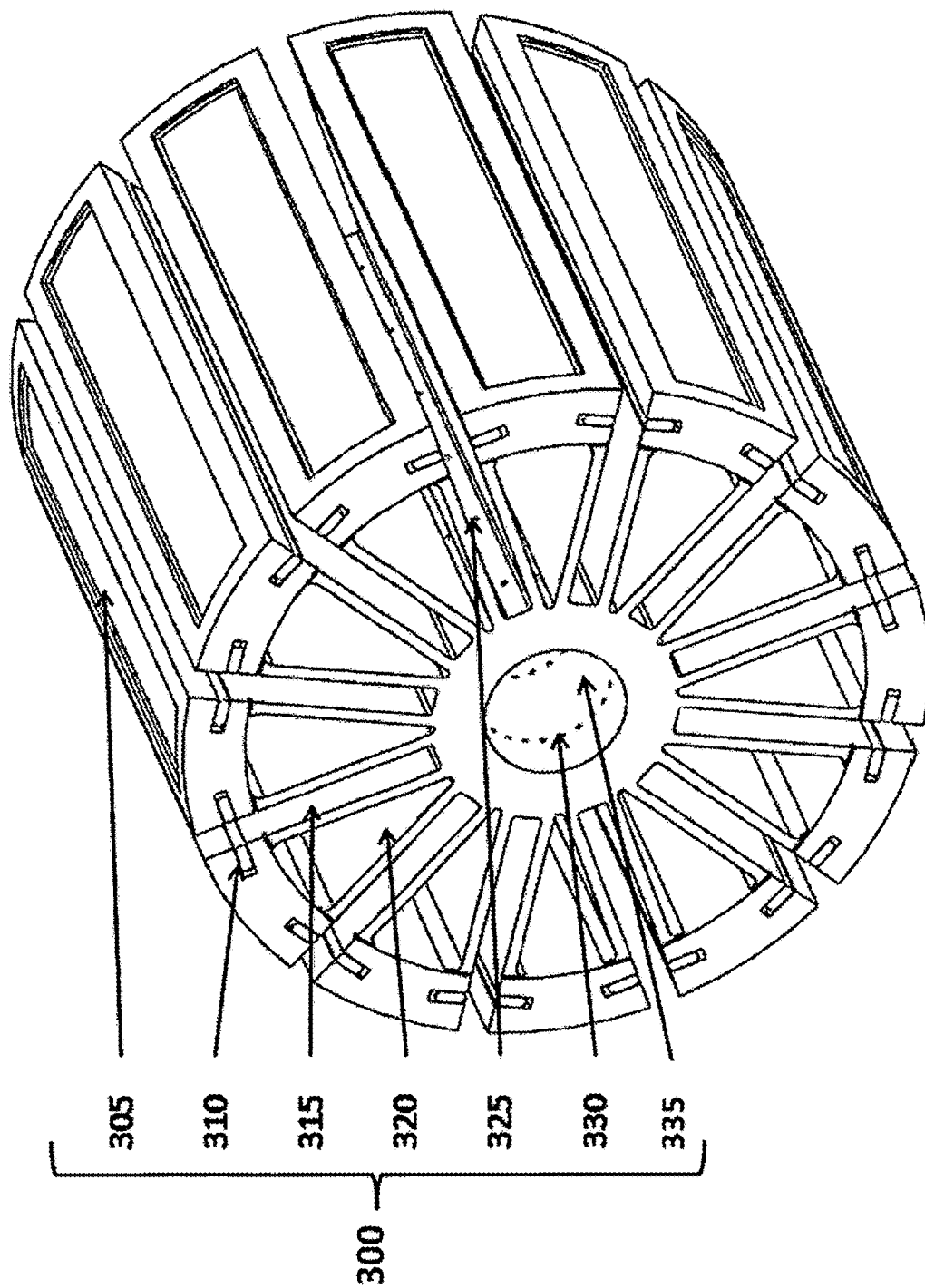


Figure 5

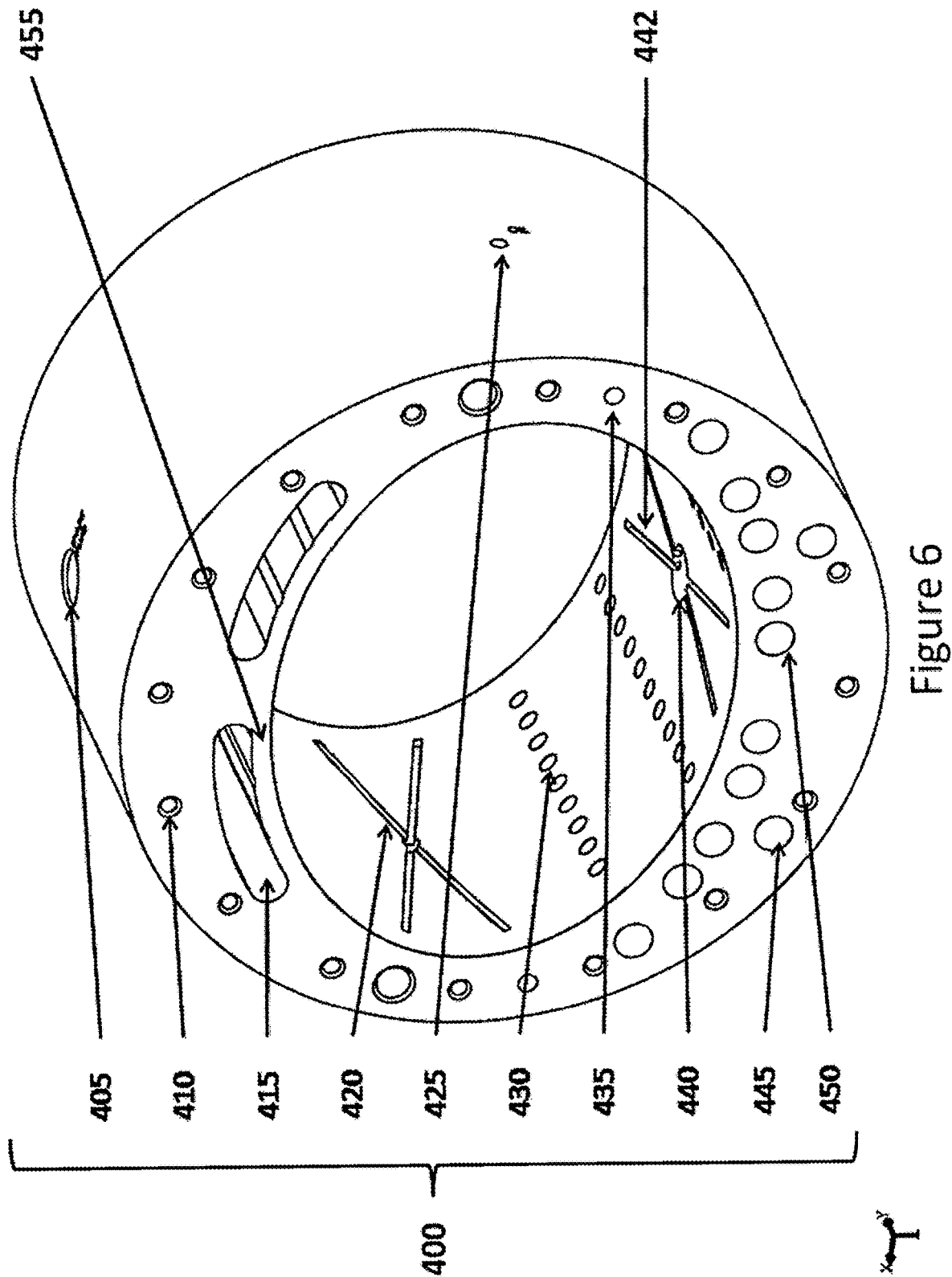


Figure 6

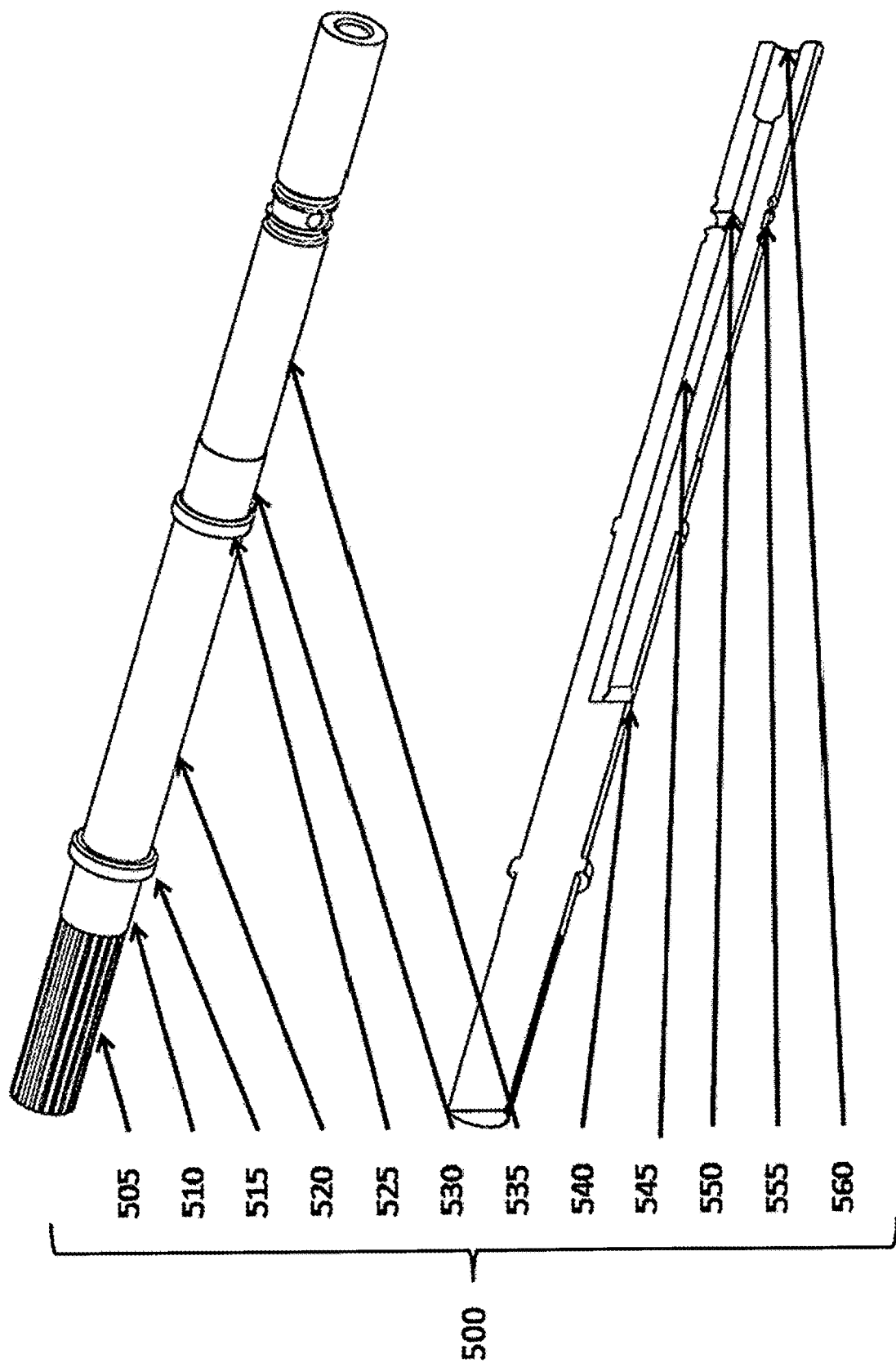


Figure 7

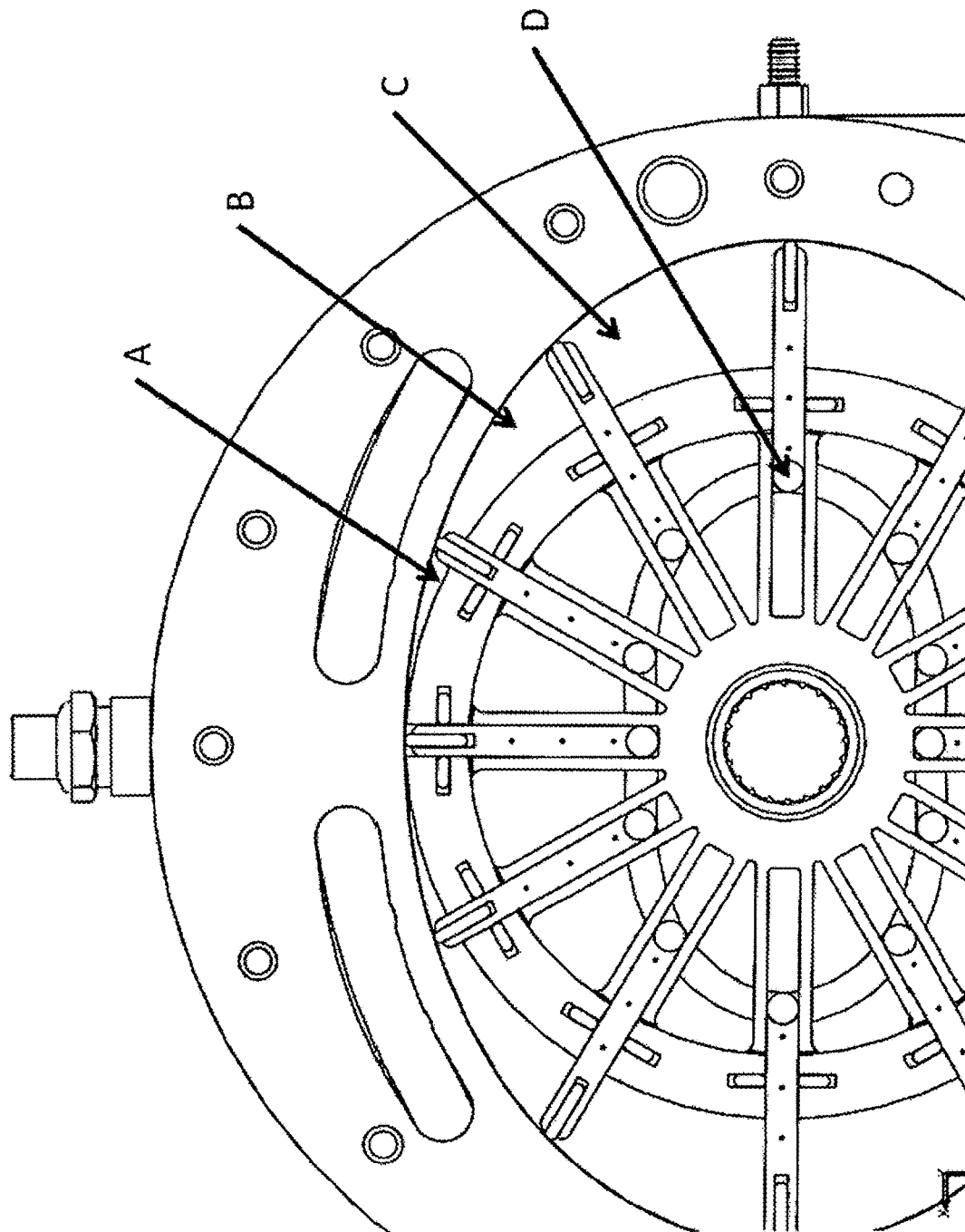


Figure 8

Given an Ellipse, Where:

a = Ellipse Major Axis

b = Ellipse Minor Axis

Then for any angle Θ , $0^\circ \leq \Theta \leq 360^\circ$ the Ellipse
X and Y Coordinates respectively are:

$$x(\text{ellipse}) = a * \cos(\Theta)$$

$$y(\text{ellipse}) = b * \sin(\Theta)$$

Then the length L from the origin to any point
on the ellipse perimeter is:

$$L = \text{SQRT}((a * \cos(\Theta))^2 + (b * \sin(\Theta))^2)$$

Given a desired fixed length pin track offset
from the Ellipse perimeter of D, then for any
angle Θ , the length from the origin to the
perimeter P of the pin track is:

$$P = L - D$$

Then for any angle Θ , $0^\circ \leq \Theta \leq 360^\circ$, Pin Track
X and Y Coordinates are a ratio of the length
from the origin of:

$$x(\text{pin track}) = a * \cos(\Theta) * (L - D) / L$$

$$y(\text{pin track}) = b * \sin(\Theta) * (L - D) / L$$

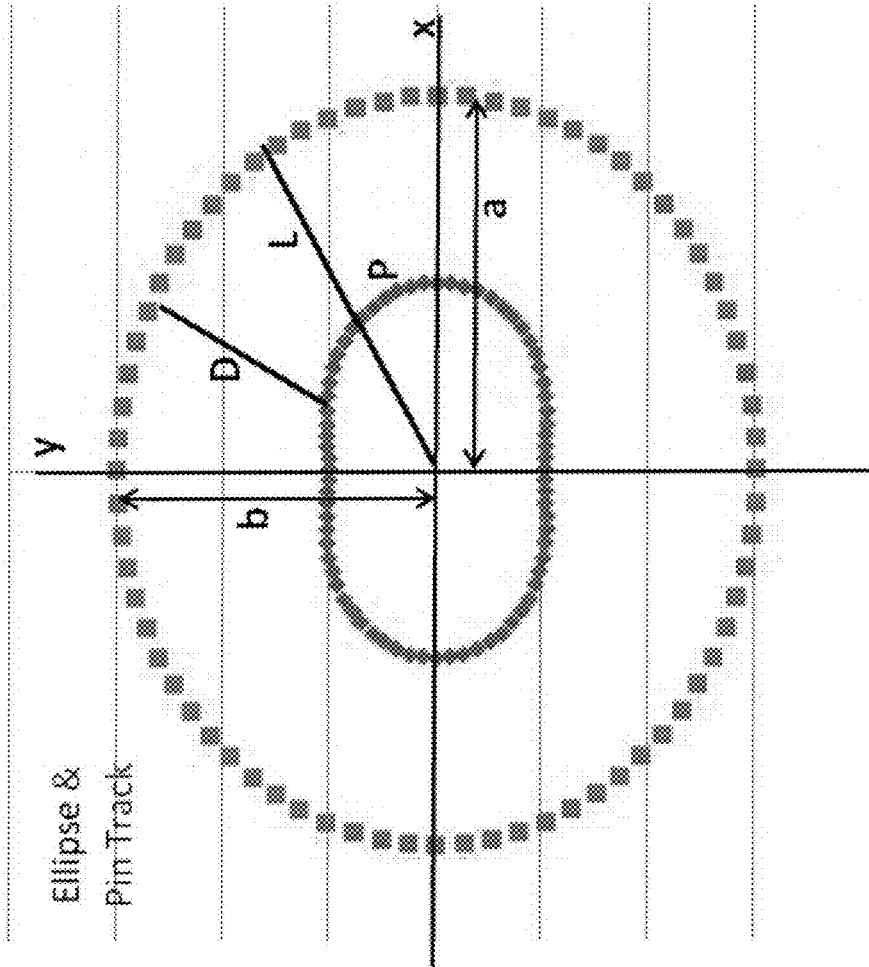


Figure 9

CIRCLE ELLIPSE ENGINE**CROSS-REFERENCE TO RELATED APPLICATIONS**

Current U.S. Class: 418/219; 418/145; 418/153; 418/261; 277/562; 277/566

Current International Class: F04C 18/00 (2006.01); F04C 2/00 (2006.01)

Field of Classification Search: 418/145-148; 418/153; 219; 265; 261; 277/551; 553; 562; 277/566; 568; 572; 581; 589

REFERENCES CITED

U.S. PATENT DOCUMENTS:				
Number	Date	Name	CPC Class	U.S. Class
1,527,685	February 1925	Huwiler	F04C2/3446	418/261
1,686,767	October 1928	Saxon	F02B53/00	123/243
2,345,561	April 1944	Allen	F01C1/3446	418/264
2,590,729	March 1952	Scognamiglio	F04C18/352	418/173
2,988,065	June 1961	Wankel	F02B53/04	123/242
3,468,260	September 1969	Belden	F04C2/3448	418/152
3,551,080	December 1970	Feller	F01C19/02	418/124
3,769,945	November 1973	Kahre	F01C1/3568	418/217
3,799,710	March 1974	Jacobs	F01C1/3448	418/147
3,865,521	February 1975	Upchurch	F01C19/08	418/121
3,873,253	March 1975	Eickmann	F01C21/0809	418/261
4,004,556	January 1977	Pfeiffer	F02B53/00	123/243
4,028,028	June 1977	Fuchs	F01C1/3448	418/219
4,325,394	April 1982	Reams	G03F7/30	134/141
4,401,070	August 1983	McCann	F01C1/3448	123/229
4,474,105	October 1984	Eicher	F15B15/12	92/122
4,573,892	March 1986	DuFrene	B62D13/00	418/219
4,575,324	March 1986	Sommer	F01C21/0809	418/217
4,667,468	May 1987	Hansen	F01C1/3441	123/248
4,799,867	January 1989	Sakamaki	F01C21/0836	418/1
5,429,084	July 1995	Cherry	F01C1/3448	123/243
5,509,793	April 1996	Cherry	F01C1/3448	123/243
5,524,587	June 1996	Mallen	F01C1/3446	123/202
5,551,853	September 1996	Cherry	F01C1/3448	418/137
5,634,783	June 1997	Beal	F01C21/3446	418/264
6,776,136	August 2004	Kazempour	F01C1/3446	123/243
7,707,987	May 2010	Guthrie	F01C1/3446	123/243
7,896,630	March 2011	Grisar	F01C1/3448	418/261

FOREIGN PATENT DOCUMENTS:			
Number	Date	Name	CPC Class
EP-0548416	June 1993	Gordon	F01C1/3448
EP-1617040	January 2006	Badgley	F01C1/3448
GB-1110162	April 1968	Eichmann	F01C19/10
GB-1430196	March 1976	Mirkovic	F15B15/103
GB-2419382	April 2006	See	F01C1/3441
JP-55098689	July 1980	Kobayashi	F01C21/0881
JP-02019601	January 1990	Hayashi	F01B003/00
WO-8503736	August 1985	Hublet	F01C21/0881
WO-0133082	May 2001	Tsutsui	F01C1/3446
WO-2006018848	February 2006	Nagler	F01C1/3441

PARENT CASE TEXT

This invention relates to rotary machines and more particularly to rotary machines which can be constructed for operation as internal combustion engines, fluid pumps, air/gas expanders, and air/gas compressors. The present appli-

cation is a continuation-in-part of my prior U.S. Pat. No. 7,896,630 filed Feb. 13, 2007 and awarded Mar. 1, 2011, which has expired.

FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not Applicable

REFERENCES—LISTINGS, TABLES, OR COMPUTER PROGRAMS

Not Applicable

BACKGROUND OF THE INVENTION

The present invention relates to a rotary device using radial reciprocating vanes whose position is controlled by a precision pin track.

Field of the Invention

Rotary devices have long been thought to be an efficient way of rotating a shaft in the case of a rotary engine, pumping a fluid in the case of a pump, and compressing a fluid in the case of a compressor. Rotary devices are generally characterized by a rotating “piston”, or the equivalent, instead of a traditional linearly reciprocating piston as found in piston engines, pumps, and compressors. However, sealing the rotating “piston” has presented an extremely challenging problem, ultimately resulting in lack of widespread adoption of this technology. The sealing problems are particularly acute in a rotary engine as compared to a pump or a compressor. This is mainly because a combustion engine typically operates at higher pressures and temperatures, and therefore requires tighter sealing than in other applications.

An inherent conflict in this technology is that tighter sealing may result in excessive friction and premature seal failure. Many different approaches have been tried to address sealing issues with rotary devices including the elimination of seals altogether and reliance instead on close tolerances and accurate machining to seal leakage. Although in principle this approach can work for lower pressure and temperature applications, it is unsuitable for the higher temperatures and pressures of rotary engines where friction and thermal expansion are present. Ultimately the rotating “piston” will get hotter than the external casing. A “piston” that is a snug fit when the rotary engine has just been started will become tighter and tighter as it heats. A further complication is that unequal heating of the various parts will lead to non-uniform expansion of the parts, resulting in changes in shape as well as in size that make sealing attempts through tolerances and accurate machining unsuccessful in rotary engines.

Rotary engines have long been thought to be a viable replacement for the standard reciprocating piston engines. Rotary engines offer possible increases in mechanical and fuel efficiency, as well as more compact dimensions and a lower weight. The major deficiencies in traditional reciprocating piston engines arise from the short stroke of the pistons which leads to incomplete combustion. In theory, rotary engines provide a continuous power stroke with decreased structural complexity, due mostly to the reduction in the number of moving parts. In practice, however, rotary engines have not received widespread acceptance and have only had limited success in replacing reciprocating piston engines, due mainly to the complexities involved in building a “simpler” rotary engine. Specifically, rotary engines typically involve a complex-shaped combustion chamber which

presents problems in sealing the combustion chamber. The inability to adequately seal the combustion chamber has led to many failed prototypes of the rotary engine.

Description of the Related Art

One rotary engine that has received some commercial acceptance is the Wankel engine, original U.S. Pat. No. 2,988,065, which has been used in some models of automobiles produced by Mazda. A Wankel engine has a triangular shaped rotor, i.e., a rotating "piston" incorporating a central ring gear which is driven around a fixed pinion within an oval shaped housing. The triangular shaped rotor creates three combustion chambers between the rotor and the interior walls of the housing as the rotor turns within the housing. Each of the three rotating combustion chambers dynamically changes in volume as the triangular rotor rotates in the oblong housing and undergoes the four stages of the Otto cycle—intake, compression, ignition and exhaust. The rotary motion is transferred to the drive shaft via an eccentric wheel that rides in a bearing in the rotor that matches the central ring gear. The drive shaft rotates once during every power stroke instead of twice as in a typical four stroke reciprocating piston engine. The Wankel engine promised higher power output with fewer moving parts than the Otto cycle reciprocating piston engine, however, technical difficulties associated with sealing the three rotating combustion chambers have apparently interfered with widespread adoption.

Another type of rotary engine is known as the axial vane rotary engine. In an axial vane rotary engine, a circular rotor is located between two cams, each cam having a cooperating undulating cam surface facing the rotor. The rotor has a series of angularly spaced slots to receive axially sliding vanes whose ends contact each of the opposing undulating cam surfaces so that combustion chambers are dynamically formed between adjacent axially sliding vanes. Axial vane rotary engines are described in U.S. Pat. Nos. 4,401,070, 5,429,084, 5,509,793, 5,551,853, and 7,896,630; all of which are herein incorporated by reference.

An axial vane rotary engine has the capacity to provide greater output than a Wankel rotary engine of the same size. However, an axial vane rotary engine presents a greater sealing challenge since the vanes slide both axially with respect to the rotor and circumferentially with respect to the cam surfaces. The present invention is directed to a rotary device of improved design over the prior art which eliminates the complex circular and axial motion of axial vanes, and facilitates the ability to adequately seal the combustion chambers formed between adjacent vanes.

The Circle-Ellipse Engine leverages the work accomplished by Mazda in sealing the combustion chamber of its Wankel engine design. Further, it leverages the contributions by Cherry (U.S. Pat. Nos. 5,429,084, 5,509,793, and 5,551,853), in promulgating the pioneer work by McCann (U.S. Pat. No. 4,401,070), in the opposing cam axial-vane rotary engine.

The Innovation

This device eliminates the complex and expensive machining associated with the epitrochoid housing and triangular central rotor of the Mazda-Wankel implementation (U.S. Pat. No. 2,988,065).

Instead, this device integrates a geometrically standard ellipse as the cam surface, and integrates a circular rotor facing the cam surface. The innovation is the pin track in the end plates. This track serves to accurately position the tip of the vane a fixed distance from the cam surface for all angles of rotation of the rotor. Now managed with constant dis-

tance, the small gap is effectively sealed by an Apex Seal identical to that of the Mazda-Wankel implementation.

Prior attempts at implementing a pin track failed. They were based on following the geometry of the cam. This was a mistake, and resulted in a varying solution of the distance from the vane tip to the cam surface.

The correct implementation in this innovation is a pin track derived from the three contributing elements; namely the cam surface (an ellipse), the rotor (a circle), and the host end plates (fixed location). The solution is a complex transcendental equation that properly integrates the geometry of the three independent components.

It is understood that one of skill in the art of rotary devices can apply the principles discussed herein in the various embodiments equally to other rotary devices such as pumps, compressors, expanders, etc.

BRIEF DESCRIPTION OF DRAWINGS

The invention will be more readily understood from the following description of a preferred embodiment thereof given.

FIG. 1 is a simplified exploded, isometric view showing a circle-ellipse engine of the invention.

FIG. 2 is an isometric view showing the inside of the end plate member of the circle-ellipse engine of the invention.

FIG. 3 is an isometric view showing the outside of the end plate member of the circle-ellipse engine of the invention.

FIG. 4 is an isometric view showing a radial vane of the circle-ellipse engine of the invention.

FIG. 5 is an isometric view showing a rotor of the circle-ellipse engine of the invention.

FIG. 6 is an isometric view showing a housing of the circle-ellipse engine of the invention.

FIG. 7 is a composite isometric view showing external and internal features of the drive shaft of the circle-ellipse engine of the invention.

FIG. 8 is a cross-section view showing a combustion chamber of the circle-ellipse engine of the invention.

FIG. 9 is a graphic explanation of the interrelationships between the pin track of the end plate, the tip of the vane, and the inner elliptical surface of the housing of the circle-ellipse engine of the invention.

DETAILED DESCRIPTION OF THE INVENTION

A circle-ellipse engine comprises a stationary circular outer housing having an inner elliptical cam surface, and a separate internal round rotor partitioned into equal segments that are populated by a quantity identical movable radial vanes. During rotation, the end of the vanes are positioned a constant distance from the elliptical inner cam surface of the housing. The internal round rotor has the same radius as the minor axis of the elliptical inner cam surface, less a small amount of designed clearance, which is completed by dynamic position of a spring loaded apex seal (not part of this invention). During rotation, a variable height cavity is created representing the difference between the item 455 elliptical cam inner surface and the item 305 rotor face combustion pocket.

The position of the radial vanes is guided by the slots in the symmetrical rotor, extending to the elliptical inner cam surface of the housing. The precise extension is governed by a pin track machined into the dual end plates.

There are no pistons, camshaft, timing chains, valves, valve lifters, rocker arms, connecting rods, or wrist pins. As

a benefit, size and weight are significantly reduced when compared to a reciprocating engine of similar horsepower. Normal aspirated air is continuously drawn into the engine when an adjacent pair of radial vanes passes the air inlet port. Similarly, exhaust products are expelled after a combustion event when the pair of adjacent vanes passes over the exhaust port.

The resultant geometry results in a continuous implementation of the Otto Cycle; namely intake, compression, expansion or power stroke, and exhaust during a single rotation of the internal rotor.

Because the Otto Cycle is executed each revolution of the rotor, the circle-ellipse engine achieves the same power as a conventional reciprocating engine of the same displacement and compression ratio, at half the RPM. This implementation greatly reduces component wear and extends the life and maintenance cycle by a factor of four. As a side benefit, the power losses and vibration common to all reciprocating engines are minimized.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is directed to a circle-ellipse engine, hereinafter referred to as the device, capable of various implementations such as an engine, a pump, a compressor, or an expander, each having the following general features: (a) first and second chamber paths allowing for a plurality of chambers to be formed between adjacent vanes; (b) the housing cam surface and rotor form parts of the chamber, and the vanes driven off a pin track on each end plate; and (c) the volume of each of the chambers dynamically changes as the rotor turns with respect to the housing's cam surface. The ability to rapidly change the volume of the chambers, and eliminate leakage between the chambers and other cavities, is crucial to the successful implementation of the device.

Referring to the figures and first to FIG. 1, there is shown a device comprised of two identical and opposing end plates, respectively items 100 and 100A, separated by item 400 housing. The housing encloses the item 300 rotor, and a plurality of identical item 200 vanes. Completing the device is the item 500 drive shaft, which is a line-to-line fit with the item 300 rotor.

Please refer next to FIG. 2 and FIG. 3, which are respectively the inside and outside of the identical end plates, respectively items 100 and 100A. Items 130 and 165 are repeated on FIGS. 2 and 3 to show the connectively relationship between the front and back sides.

Two identical water plenums, in the end plate, respectively upper 105 and lower 135, provide for passage of cooling water from the external water fitting locations, respectively upper 150 and lower 170, into the circle-ellipse engine. The cooling water is then directed to appropriate water passageways in the item 400 housing to provide thermal stability. Cooling water enters through item 150, an external water inlet port. The cooling water fills item 105 upper water plenum on the same item 100 end plate. Cooling water is passed through housing item 415 cooling water passageway, which passes on each side by the top of the rotor item 305 combustion chamber. Now warmed by absorbing elevated combustion heat, cooling water next passes to item 105 water plenum on the opposite item 100 end plate.

The warmed cooling water is looped by an external hose (not part of this device). The hose is next connected to the lower item 170 water inlet port on the same item 100 end

plate. As described above, the warmed cooling water passes to the item 105 water plenum, then the item 450 water channels in the item 400 housing, next to the lower item 135 water plenum, expelled to the item 170 water fitting, and lastly connected to an external filter, radiator, and water pump (which are not part of this device).

Item 415 cooling water passageway has a large surface area. This helps to maximize heat transfer from the item 400 housing to the cooling water. The item 300 rotor and item 200 vanes are oil cooled, and will be described shortly.

Items 110 and 145 are the inside and outside locations for one of the 16 socket head screws to fasten the end plates 100 and 100A to each end of the item 400 housing.

Item 115 is a cavity suitable for securely mounting thrust and roller bearings respectively in each end plate 100 and 100A. By mounting the bearings on the inside of the end plates, secure mounting is assured. This innovation compensates for internal thermal expansion of the device, based on a similar implementation in gas turbine engines.

Item 120 is a pin track. It is a calculated path based on complex transcendental mathematics as shown in FIG. 9. It serves to precisely position the vanes tips such that they are maintained a constant distance from the item 455 inner cam surface of the item 400 housing, for all angular positions of the item 300 rotor.

Item 125 is one of two locations for accurately positioning a hard pin. The two pins serve to precisely locate the end plates with regards to the housing, ensuring proper alignment during assembly.

Items 130 and 165 are the inside and outside locations for one of four identical air inlet/exhaust fittings. These convey passage of air/exhaust to/ from the inside of the item 455 elliptical cam surface of the item 400 housing.

Two mounting holes items 140 and 140A are provided for securing the device to a suitable base.

Items 155 and 175 are two of the identical six pre-threaded hard points for attaching accessories, such as an alternator, water pump, oil pump, and/or power steering pump as needed. These accessories are not part of the device.

Two item 160 pre-threaded lubrication ports are provided for attaching flow restrictors. The flow restrictors have a 0.060-inch diameter aperture to provide a specific amount of lubrication oil. Pin track lubrication is required for item 215 pin of item 200 vane, as it navigates around the item 120 pin track of item 100 and 100A end plates. Without sufficient lubrication, the item 215 pins of item 200 vanes could bind in the item 120 pin tracks of the identical item 100 and 100A end plates. Conversely too much lubrication oil could overflow the item 120 pin track and cause undesirable entry of lubrication oil into item 305 combustion chamber of item 300 rotor.

Please refer next to FIG. 4, which is the radial vane, item 200. A plurality of vanes are inserted into item 315 vane slots. These partition the item 300 rotor into separate chambers suitable for combustion events.

Item 205 provides a location slot for mounting the apex seal. The apex seal (not part of this invention) transverses the precisely defined distance from the tip of the item 205 vane slot to item 455 elliptical cam surface.

Item 210 is one of many internal lubrication ports, which guide lubrication oil from the source, item 330 lubrication ports of item 300 rotor, to each external surface of the Item 200 vane. These pre-drilled ports provide for a precise and minimal amount of oil to lubricate the vane interface with

the end plates, respectively **100** and **100A**, the item **315** vane slots, and the item **205** apex seal slot, and item **310** face seal cavity.

Without sufficient lubrication, item **200** vanes could bind in the item **315** vane slots of item **300** rotor. Conversely too much lubrication oil entering from item **325** rotor lubrication ports or item **210** vane lubrication ports could overflow the item **315** vane slot and cause undesirable entry of lubrication oil into item **305** combustion chamber of item **300** rotor.

Item **215** is the pin that interfaces respectively with the pin tracks in end plates **100** and **100A**. The pin serves to precisely control the position of the vane **200** based on its instantaneous position of the item **300** rotor.

Item **220** is the face of the vane that interfaces with item **315** vane slots in item **300** rotors. This face receives lubrication oil from item **330** oil passageways in the rotor.

Please refer next to FIG. **5**, which is the item **300** rotor. The rotor is the major moving component of the device. It is partitioned into a plurality of identical segments, each of which independently forms a part of the combustion chambers.

Item **305** is one of a plurality of identical combustion surfaces. During rotation, when this rotor surface is closest to the item **455** elliptical cam surface of the item **400** housing, there is maximum compression. At this point there is minimum extension of a pair of adjacent item **200** vanes.

Item **310** is one of a plurality of identical side seal slots. When populated with side seals, these slots ensure positive and low friction sealing of the radial vanes in the combustion chamber. This prevents the leakage of combustion products into lubrication oil, contaminating the oil, and leakage of unwanted oil into the combustion chamber to help minimize Nitrogen-Oxygen (NOx) pollutants.

Item **315** is one of a plurality of identical vane slots. When populated with item **200** vanes, these slots ensure positive and low friction radial motion of the vanes. The slots are sealed on both ends respectively by end plates **100** and **100A**.

Item **320** is one of identical lubrication oil chambers. These provide appropriate amounts of lubricating oil and thermal cooling to each vane slot and the item **300** rotor that interfaces with both end plates, respectively items **100** and **100A**.

Item **325** is one of many identical lubrication ports, 12 per each vane slot), that provide lubrication oil to each of the identical lubrication oil chambers **320**, and each of the item **315** vane slots. Each of the chambers and slots contain six entry ports, which provide even distribution of lubrication oil throughout the device. The item **325** lubrication ports are pre-drilled to 0.060-inch diameter and provide for a precise and minimal amount of oil to lubricate the vane interface.

Item **330** is the location of one of the lubrication ports connecting to the opposite end of the item **325** lubrication ports. In conjunction with item **500** drive shaft, these ports are the exit locations of the rotor manifold, which is fed from the hollow item **500** drive shaft.

Please refer next to FIG. **6**, which is the item **400** housing. The housing is the major static, non-moving component of the device. It accommodates passageways for cooling water, natural aspirated air, exhaust products, and distribution lubrication/cooling oil.

Item **405** is the spark plug port. For a compression ignition engine implementation of this device, it is the location of the fuel injector.

Item **410** is one of 16 identical threaded holes to accommodate socket head mounting screws that secure the end plates **100** and **100A** to the housing.

Item **415** is a cooling water passageway. It is a direct interface to the water source port, end plate Item **150**, which in turn supplies the upper end plate water distribution manifold Item **105**. The extensive size of the passageway is to provide thermal stability to the item **400** housing.

Item **420** is one of two identical internal lubrication oil distribution tracks that lubricate the working surface of the apex seals from item **205** vane slot of item **200** vane.

Item **425** is one of two identical external ports for the attachment of oil flow restrictors, which in turn feel lubrication oil to oil distribution tracks Item **420**. The flow restrictors have a 0.060-inch diameter aperture to provide a limited and specific amount of lubrication oil. The flow restrictors ensure proper oil lubrication is applied to the apex seals, (not part of this invention) which are mounted in item **205** apex seal slots. These lubricate the interface between the apex seals and the inner cam surface of the housing item **455**, and minimize the amount of unwanted oil into the combustion chamber which minimizes formation of Nitrogen-Oxygen (NOx) pollutants.

Item **430** is one of 36 air/exhaust ports that connect air/exhaust from the end plates items **130** and **165**, through housing Item **445** and into the inside elliptical cam surface of the housing item **455**. The ports are arranged in four segments of nine openings each. This is to minimize the disruption and wear on the apex seals, ensure even distribution, and define the proper distance between an adjacent pair of item **200** vanes.

Item **435** is one of two locations for accurately positioning a hard pin. The two pins serve to precisely locate the item **125** end plates with regards to the housing, ensuring proper alignment during assembly.

Item **440** is the lubrication oil exit port. The lubrication oil that enters each of the Item **425** ports is swept into the internal lubrication oil scavenge track and drained into the oil sump, which is not part of the device. Scavenged oil foam is removed by baffles in the sump, before it is respectively conveyed to an oil filter and pump. The lubrication oil that enters each of the item **425** ports is swept into the four internal lubrication oil item **442** scavenge tracks and drained into the item **440** is the lubrication oil exit port.

Item **445** is the mating location for each of the four identical air/exhaust ports to/from the end plate Items **130** and **165**. These convey passage of air/exhaust to/from the inside of the elliptical cam surface of item **430** housing.

Item **450** is one of eight identical cooling water passageways. It is a direct interface to the water source port, end plate Item **135** which in turn feeds lower end plate water distribution manifold Item **135**. The extensive size of the passageway is to provide thermal stability to the item **400** housing.

Item **455** is the inside elliptical cam surface of the item **400** housing. The geometry is an ellipse with a major and minor axis. This simple cam surface supersedes all complex, prior attempts to satisfy the requirement for a continuously changing height of the combustion chamber. Prior efforts included complex sinusoidal implementations, which were characterized by high acceleration ramp changes. Unfortunately, these resulted in intensive wear patterns, including chatter, gouging, and ripple effects on the ramp. Complex lubrication was requiring for these implementations, resulting in residual oil in the combustion chamber which lead to excessive nitrogen-oxygen (NOx) products.

Please refer next to FIG. **7**, which is the item **500** drive shaft. The drive shaft is the component of the device that couples all generated power to the load. It integrates an internal passageway that provides cooling and lubrication oil

to all rotary components. Because its function is novel, two views, external and cut-away, are provided, to help understand the description.

Item **505** is a spline section of the drive shaft. It has a standard 16 rib spline compatible with many devices such as transmissions and gear boxes.

Items **510** and **530** serve an identical purpose. They provide a line-to-line press-fit interface for the bearings, which are housed inside the end plates in a cavity Item **115**.

Items **515** and **525** provide a line-to-line press-fit interface for the item **300** rotor. This section between the two collars has a slightly reduced diameter and forms the opposite ends of an oil manifold.

Item **520** is the oil manifold. It provides symmetrical distribution of cooling and lubricating oil to the item **300** rotor through **144** ports discussed earlier as rotor Item **325**.

Item **535** is a section of the drive shaft that supports the attachment of a commercial rotary union. The rotary union facilitates connection of cooling and lubricating oil to the rotating drive shaft.

Items **540**, **545**, and **550** are shown in the cut-away view of the item **500** drive shaft and are interrelated to the injection and distribution of cooling and lubricating oil. Item **550** is the inlet port, which is mated with the commercial rotary union discussed in the prior paragraph. Item **545** is the internal passageway that connects the inlet to outlet port **540**. The outlet port is located in the center of the item **300** rotor manifold, and distributes oil to the **144** ports of the rotor, Item **330**.

Item **555** are grooves in the drive shaft that provide the structure for installation of O-rings to seal the sides of the commercial rotary union to the drive shaft and eliminate oil leakage.

Item **560** is a threaded hole for an end cap. In order to machine the internal passageway Item **545** in the drive shaft, an access means is required. After machining, a commercial screw cap is used to seal the opening.

Please refer next to FIG. **8**, which is a cross-section view of the assembled device, with one section (quadrant) highlighted.

The six-sided chambers are formed by the inner cam surface of item **400** housing, item **300** rotor, a pair of adjacent item **200** vanes, and (not shown) end plates **100** and **100A**.

As the item **300** rotor turns clockwise, the combustion chamber pointed by Index A is a very small, expanding chamber which is manifest when the item **300** passes the top-center of the inner cam surface, just past the top of elliptical minor axis.

As the rotor continues to turn clockwise, the chamber expands, as shown by Index B.

The maximum chamber height, as shown by Index C, occurs when rotor reaches a horizontal position of the inner cam surface, which is the elliptical major axis.

As the rotor continues to turn clockwise, the cycle repeats these steps in reverse sequence.

Index D is a related feature. It is pointing to vane pin **215**. This pin is assembled into pin track **120** of end plates **100** and **100A**. It is this pin track that determines the position of radial vane **200**, and its extension beyond the perimeter surface of item **300** Rotor.

Please refer next to FIG. **9**, which shows the relationship of the pin track, shown as its perimeter P, and the cam surface of item **455** housing. Prior implementations, notably U.S. Pat. No. 7,896,630, implemented a simple offset of the

vane tip from the cam surface. This earlier implementation created a variable distance which made sealing very challenging.

It will be understood by a person skilled in the art that although the device shown in FIGS. **1** through **9** is a circle-ellipse engine, the device can be implemented in other embodiments including a pump, a compressor and an expander.

While preferred embodiments of the present invention have been described, it is to be understood that the embodiments are illustrative only and the scope of the invention is to be defined solely by the appended claims when accorded a full range of equivalence, many variations and modifications naturally occurring to those of skill in the art from a perusal hereof. As is readily apparent the system and method of the present invention is advantageous in several aspects.

What is claimed is:

1. A circle-ellipse engine comprising:

an identical pair of end plates, assuring exact placement of the vane tip for all rotation angles;
wherein said end plates have an internal pin track;
wherein said end plates incorporate provisions for accepting aspirated intake air;
wherein said end plates incorporate provisions for exhausting combustion product gases; and
wherein said end plates incorporate an internal race to accept either a thrust bearing or a roller bearing on the inside race of each of the identical pair of said end plates;

a plurality of vanes, each including apex seal slots: a plurality of spring-loaded apex seals to close the gap between the vane tip and the inner elliptical cam surface of the housing;

a rotor, including combustion chambers and face seal cavities;

a plurality of spring-loaded face seals prevent leakage of the exhaust gas and of unwanted lubrication oil into said combustion chamber;

a drive shaft including an internal passageway for supplying cooling and lubrication oil;

inlet ports for aspirating air into said housing;

exhaust ports for expelling exhaust gas out of said a housing containing passageways; and

dual pin tracks;

wherein the plurality of said vanes are positioned in relationship to an inner elliptical cam surface of the housing by said dual pin tracks;

wherein said dual pin tracks integrates said rotor, the plurality of said vanes and said housing to assure a displacement of a tip of the plurality of said vanes in all rotation angles; and

wherein the lubrication oil is delivered to said dual pin tracks via lubrication oil ports attaching to flow restrictors.

2. The circle-ellipse engine of claim 1,

wherein said housing includes an inner elliptical cam surface and provides feed through provisions for all fluids and gases;

wherein the lubrication oil ports on said end plates align with lubrication oil passageways in said housing for all the rotating and oscillating parts;

wherein the air intake ports on said end plates align with air passageways in said housing to supply the combustion chambers;

wherein the water intake ports on said end plates align with water passageways in said housing to provide thermal stability; and
wherein the exhaust ports in said end plates align with exhaust passageways in said housing to facilitate removal of combustion gases; and
further including internal lubrication oil distribution tracks for lubricating and for recovering excess lubrication oil during each complete revolution of the said rotor.

3. The circle-ellipse engine of claim 1, wherein said rotor further includes:

- a radius being equal to that of the minor axis of the inner elliptical cam surface of said housing, and partitioned into equal and symmetrical segments interspersed by radial movement the plurality of said vanes to from combustion surfaces;
- an internal hub of the said rotor having a cooling and lubrication oil manifold to reduce friction of said rotor, the plurality of said vanes and said drive shaft;
- a plurality of face seal slots, each of the plurality of said face seal slots has internal passageways to facilitate movement of lubrication oil;
- a plurality of oil chambers to insure continuous lubrication oil flow; and
- a pair of internal oil manifolds to insure lubrication oil is contained within the center hub of the said rotor; and
- a plurality of hemispherical pockets to optimize the location and timing of sequential and continuous combustion events.

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