United States Patent [19]

Mesa

[11] **3,776,202**

[45] **Dec. 4, 1973**

[54] **ROTARY ENGINE WITH SUN GEAR DRIVE**

[76] Inventor: **Bernardo E. Mesa,** 5912 N. Tuxedo St., Indianapolis, Ind. 46220

[22] Filed: **May 25, 1972**

[21] Appl. No.: **256,698**

[52] **U.S. Cl.** **123/8.47,** 418/36

[51] **Int. Cl.** **F02b 55/14**

[58] **Field of Search** 123/8.47; 418/34, 418/35, 36

[56] **References Cited**

UNITED STATES PATENTS

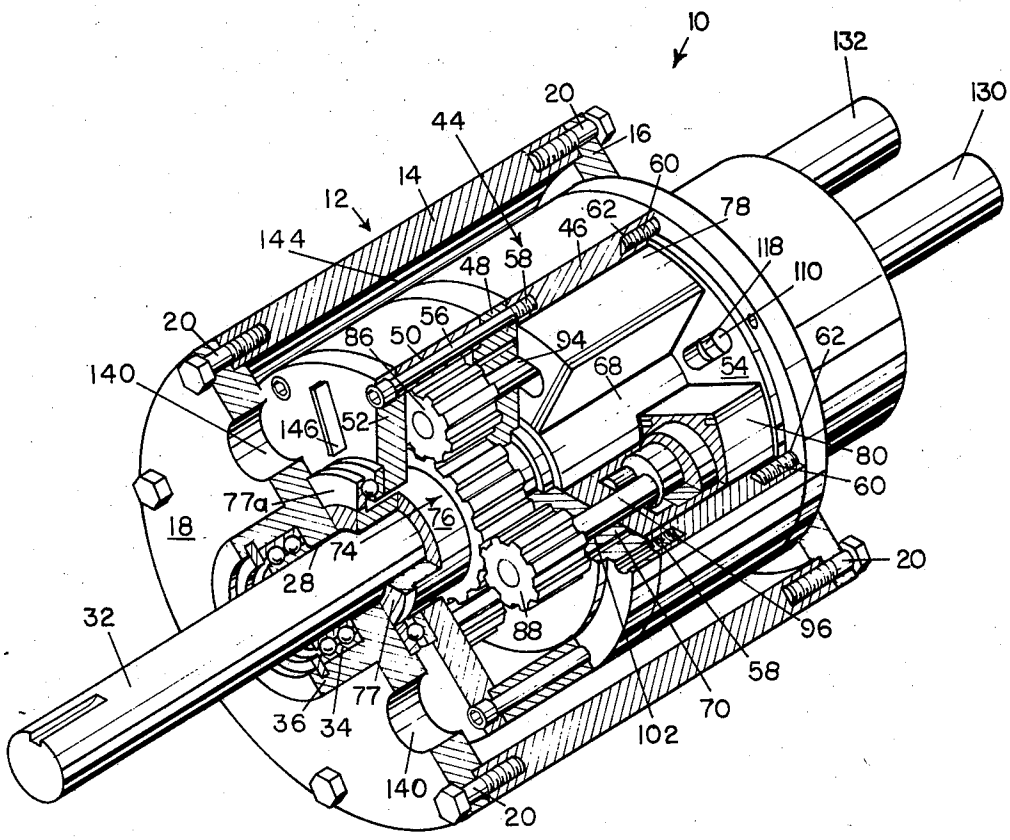
726,353	4/1903	Sainsevain	123/8.47
1,726,461	8/1929	Weed	418/36 X
1,973,397	9/1934	Stromberg	418/36 X
3,327,692	6/1967	Keagle	418/36 X

Primary Examiner—Carlton R. Croyle
Assistant Examiner—Michael Koczo, Jr.
Attorney—William R. Coffey

[57] **ABSTRACT**

An engine comprising a cylindrically shaped rotor, a support frame defining an axis for the rotor, a sun gear concentric with the said axis, a shaft for journal mounting the rotor for concentric rotation about the said axis on the frame and relative to the sun gear, the rotor providing a toroidal chamber concentric with the said axis, and conformingly shaped pistons disposed in the chamber for oscillatory movement about the axis relative to the rotor to define variable volume combustion chambers within the rotor. Planet gears are journal mounted on the rotor and meshed with the sun gear to be driven when there is relative rotation between the rotor and sun gear, and eccentrics drivingly connect each piston to one of the planet gears whereby such relative rotation produces such oscillation of the pistons relative to said chamber.

21 Claims, 16 Drawing Figures



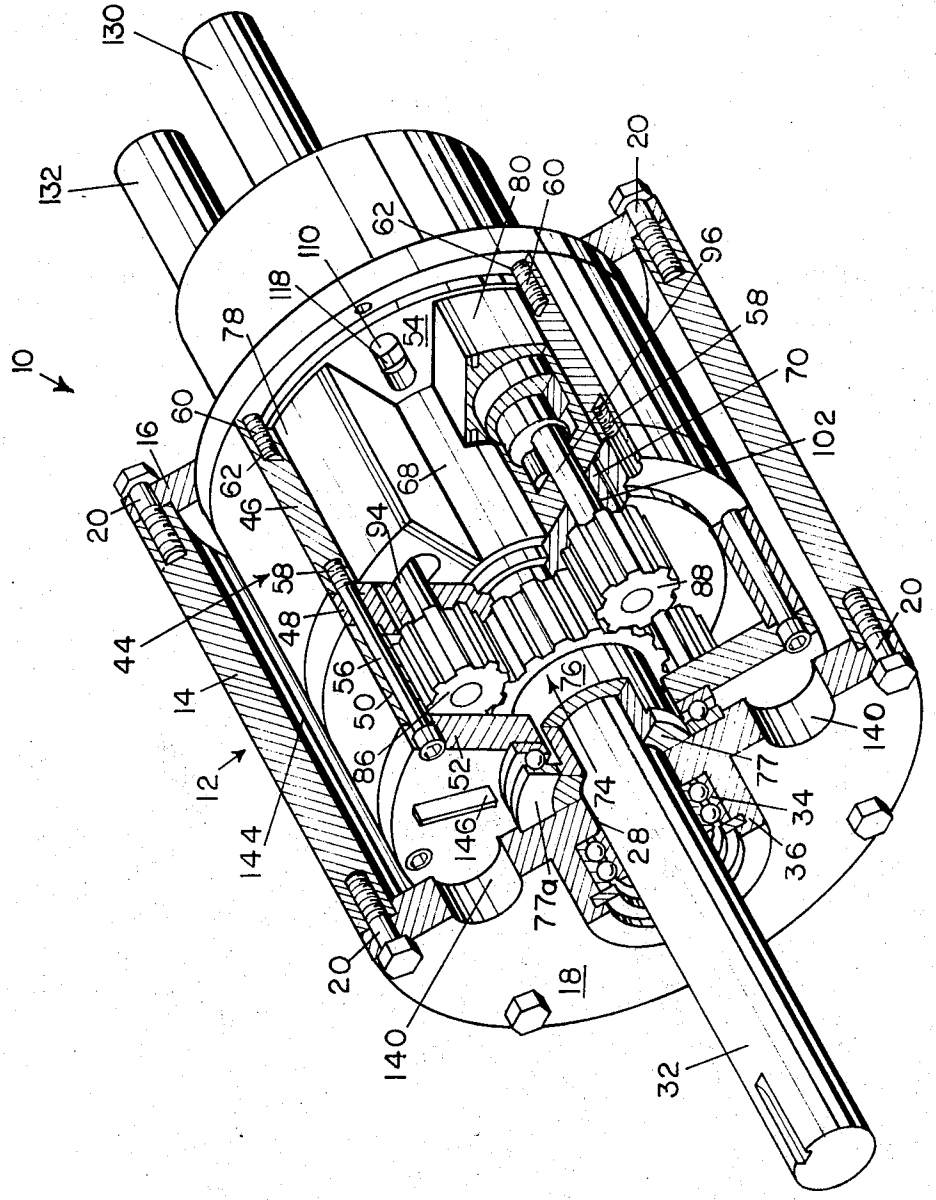

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FIG. 1

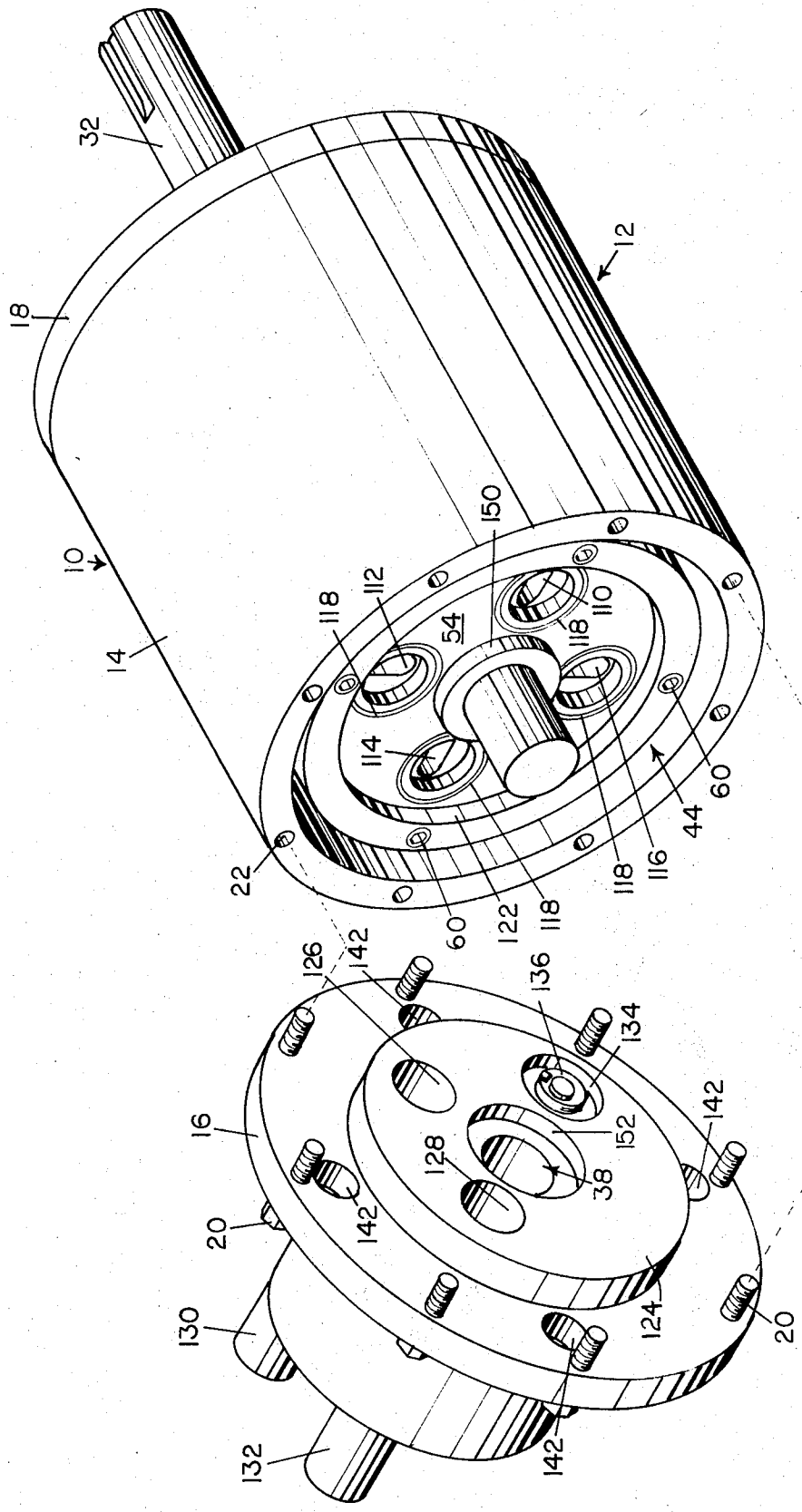

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FIG. 2

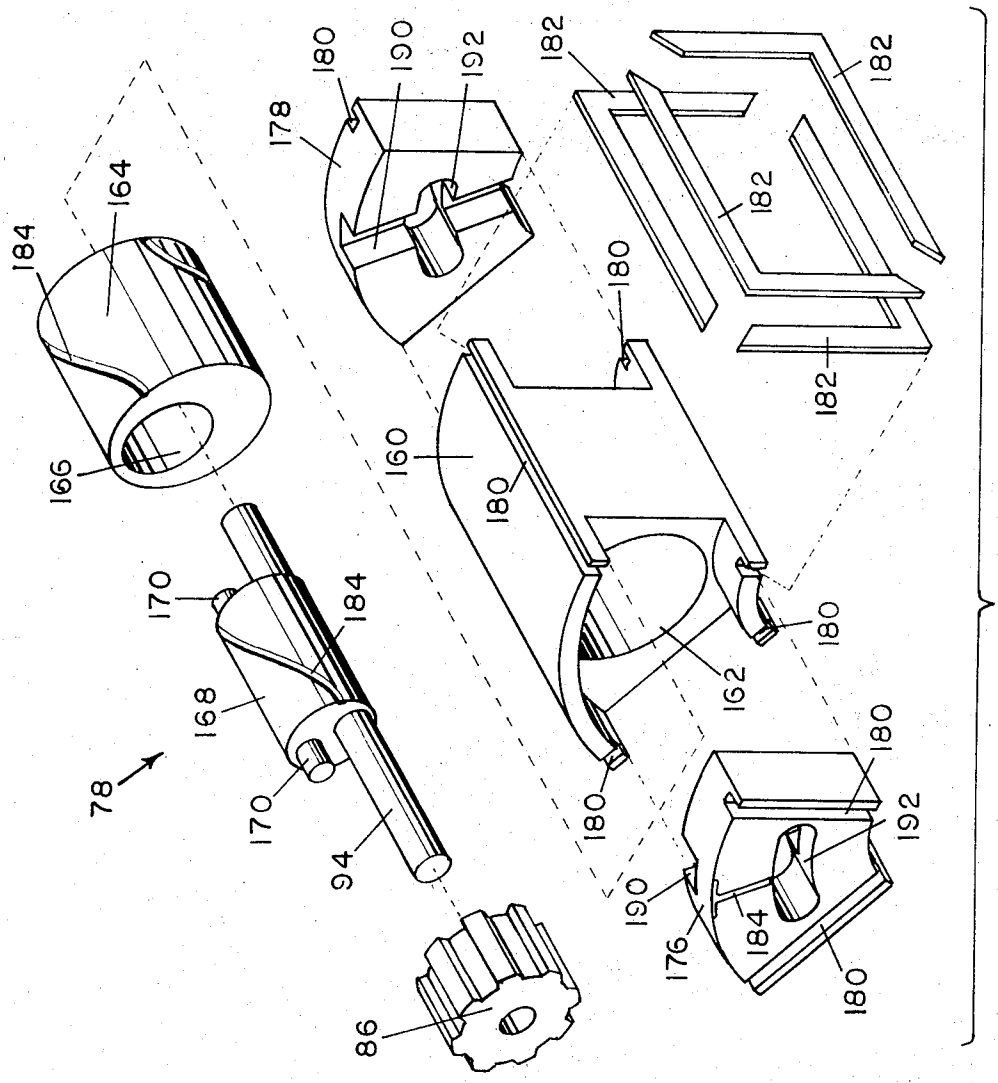

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FIG. 3A

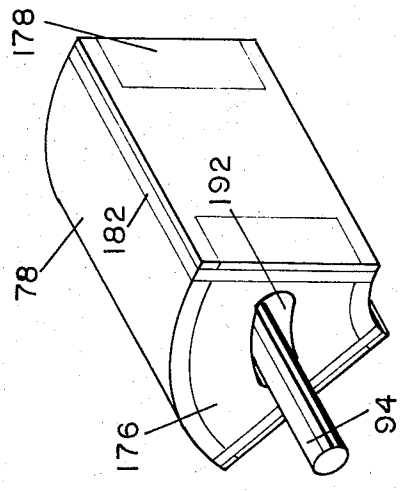

178
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FIG. 3

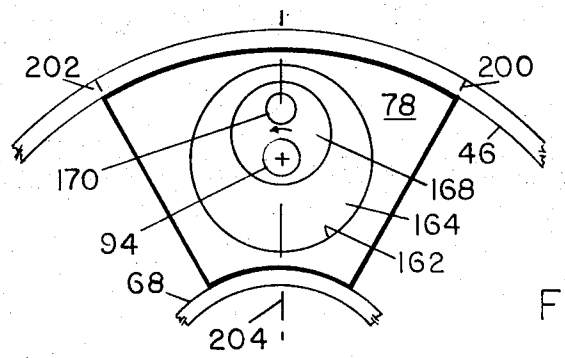


FIG. 4

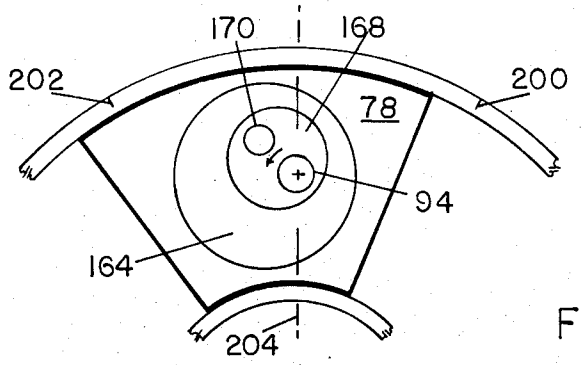


FIG. 5

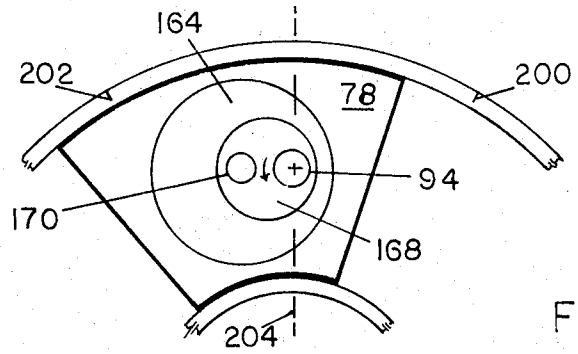


FIG. 6

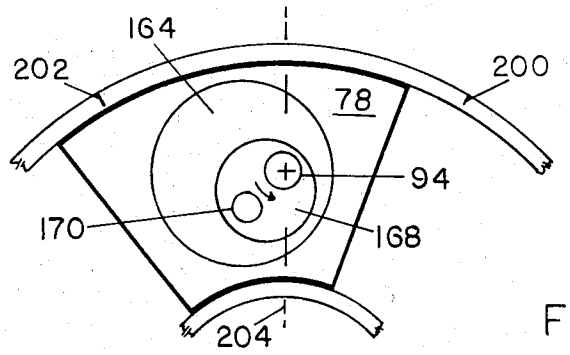


FIG. 7

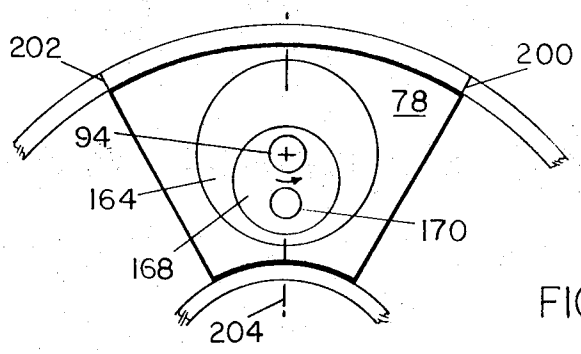


FIG 8

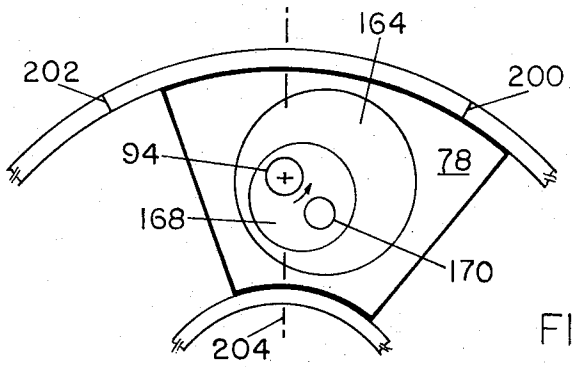


FIG 9

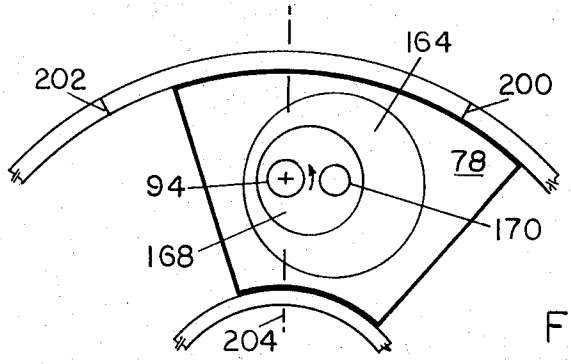


FIG 10

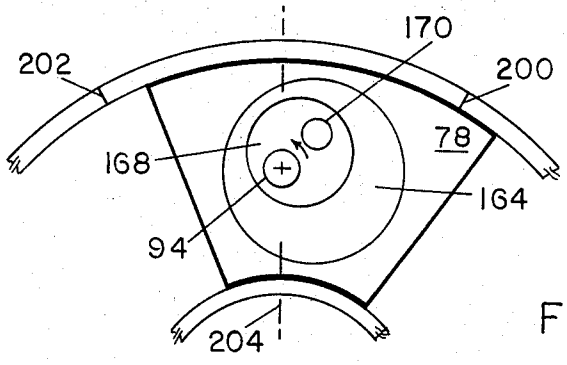


FIG 11

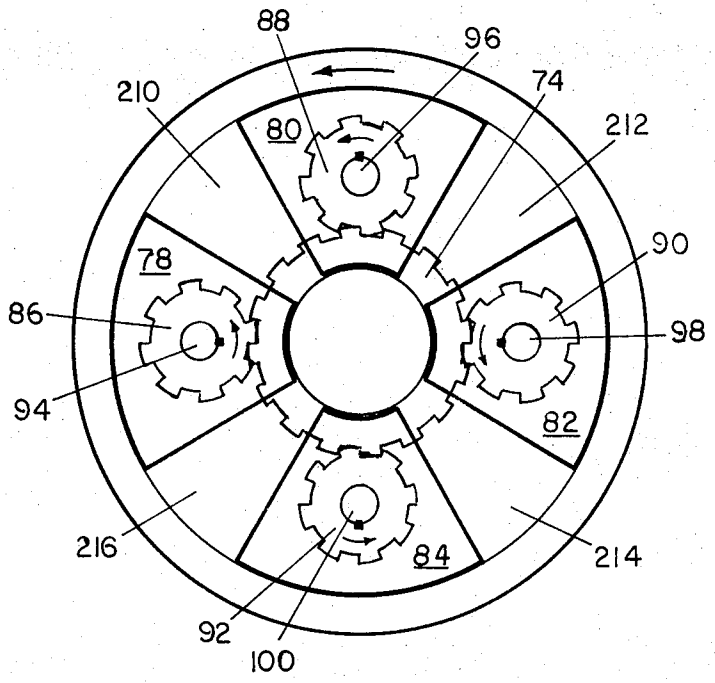

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FIG. 12

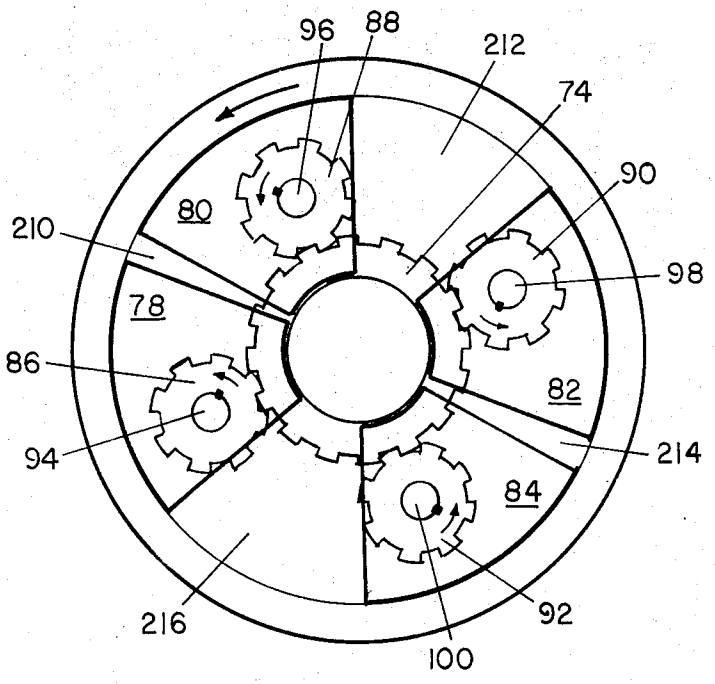

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FIG. 13

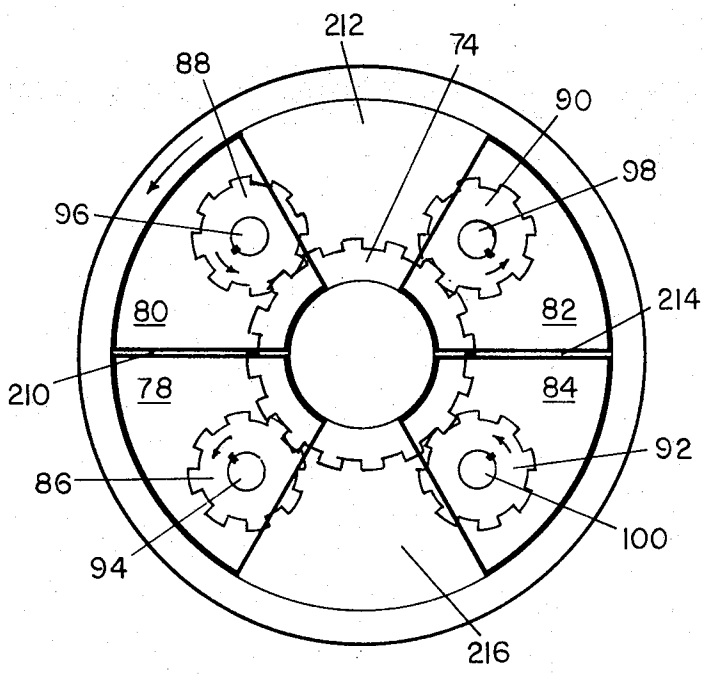

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FIG. 14

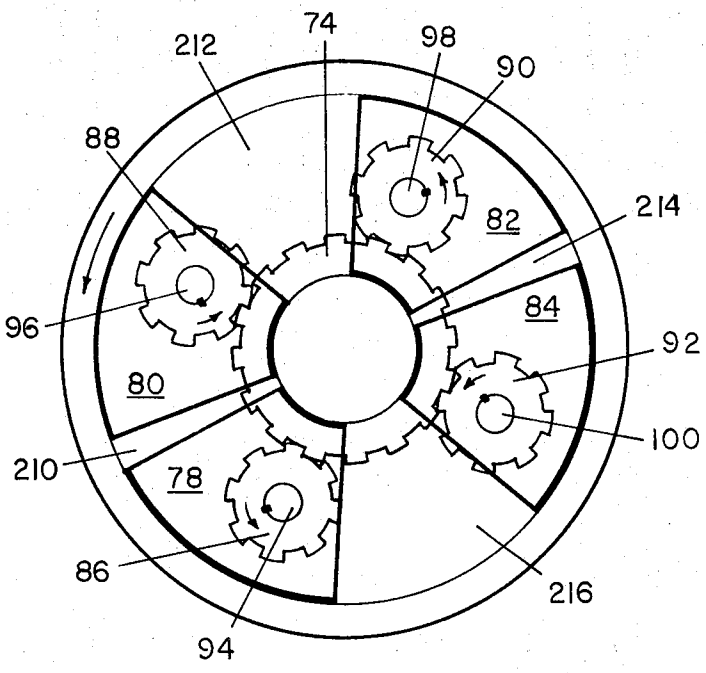

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FIG. 15

ROTARY ENGINE WITH SUN GEAR DRIVE

It is a primary object of my invention to provide an improved rotary piston engine of the type including a toroidal chamber divided into variable volume combustion chambers by pistons which oscillate within the toroidal chamber about its axis. Another object of my invention is to provide a basic drive system for a toroidal chamber and piston structure which may be used for combustion engines, steam engines, pumps, compressors and the like.

Basically, my engine includes a rotor providing a toroidal cavity hermetically enclosed and terminated at both ends with a center shaft. Fitting internally are, for instance, four pistons which divide the cavity into four variable volume combustion chambers. The pistons are oscillated within the cavity about the axis of the rotor.

This type of rotary piston engine has been the subject of many patent applications and issued patents. Among the issued patents are U.S. Pat. Nos. 3,580,228; 3,565,049; 3,398,643 and 3,144,007. The concept of an engine based on a toroidal cavity with fitting pistons and oscillatory or "stop and go" motion is not new; on the contrary, because of the obvious advantages in volumetric efficiency, positive piston action and rotary valve action, innumerable patents have been granted to inventions having this kind of toroidal configuration. In his book entitled Rotary Piston Machines published by Illife of London, Felix Wankel, the famous inventor of the Wankel engine presently receiving so much publicity, analyzes and classifies known rotary engine mechanisms. Wankel classifies engines based upon the toroidal cavity concept as "central axis machines" assuming that they necessarily must have two axes placed concentrically and with at least one of them moving at variable speed. Wankel discusses the theoretical advantages of such central axis machines concluding that they are fundamentally impractical due mainly to the complexity of the driving mechanisms which could include elliptical gears, cam followers, counterweights, and the like.

By my present invention, I have provided a basic and simple and yet effective drive mechanism which produces oscillation of the pistons as the rotor rotates to solve this long-standing problem recognized by Wankel. Particularly, I have provided a sun gear drive mechanism which is extremely simple and inexpensive as compared to the drive mechanisms of the prior art.

Basically, my engine comprises a cylindrically shaped rotor, a support frame defining an axis for the rotor, a sun gear concentric with the axis, shaft means for journal mounting the rotor for concentric rotation about the axis on the frame and relative to the sun gear, the rotor providing a toroidal chamber or cavity concentric with the axis, and conformingly shaped pistons disposed in the chamber for oscillatory movement about the axis relative to the rotor to define variable volume combustion chambers within the rotor. Planet gears are journal mounted on the rotor and meshed with the sun gear to be driven when there is relative rotation between the rotor and sun gear. Eccentric means drivingly connect each piston to one of the planet gears whereby relative rotation between the rotor and the sun gear about the axis produces oscillation of the piston relative to the rotor chamber.

My illustrated and preferred embodiment includes two pairs of pistons defining four of the said variable volume combustion chambers, the pistons of each pair being diametrically oppositely disposed. The sun gear preferably has a first diameter and a first number of teeth while each said planet gear has one-half the said first number of teeth and is of one-half the said first diameter. Further, the eccentric means for each pair of pistons are in phase so that the pistons of each pair oscillate together about the axis. The eccentric means for one of the pairs of pistons is 180° out of phase with the eccentric means for the other pair of pistons whereby diametrically oppositely disposed combustion chambers are simultaneously at their maximum and minimum volumes.

Further, in the illustrative and preferred embodiment, an end wall of the rotor provides four equally peripherally spaced ports in communication with the toroidal chamber, and the frame includes a mating stationary end wall in sliding engagement with the rotor end wall, the stationary end wall providing an intake port and an exhaust port. Each of the intake and exhaust ports are disposed sequentially to register with the four ports in the rotor end wall to supply a fuel mixture to and remove exhaust from the said combustion chambers. Further, the stationary end wall provides a third port disposed sequentially to register with the said four ports, and a spark plug is disposed in this third port sequentially to be exposed to the combustion chambers.

In the illustrative and preferred embodiment, each piston is provided with a cylindrically-shaped bore, the axis of which is parallel to the rotor axis. In this embodiment, each eccentric means includes a first cylindrically shaped eccentric axially disposed in the bore of its associated piston for rotation therein, the first eccentric having a second bore formed therein on an axis parallel to and spaced apart from the cylinder axis of the first eccentric. A second cylindrically shaped eccentric is axially disposed in the second bore for rotation therein, and this second eccentric is drivingly connected by a shaft to its associated planet gear. The second eccentric is mounted on this shaft for rotation therewith, the axis of the shaft being parallel to and spaced apart from the cylinder axis of the second eccentric. The associated planet gear is also mounted on this shaft for rotation therewith. The shaft extends through one end wall of the toroidal chamber.

It will be appreciated that my engine is ideally suited for operation as a four-cycle engine. As adjacent pistons separate, a fuel mixture is drawn into the combustion chamber therebetween as the intake cycle. Then the pistons move toward each other to compress the fuel mixture which cannot escape because the port is closed. This is the compression cycle. Then ignition occurs causing an explosion which forces the pistons to separate to provide a propelling force for the rotor. Then the pistons move toward each other to force the exhaust gases out through the port which is open. At the end of this exhaust cycle, the pistons begin to move away from each other to begin again the intake cycle. It will be appreciated that, at any given time, all four chambers are in operation, each one involving one of the four cycles. Thus, the rotor is propelled by four ignition cycles each revolution.

Other objects and features of the present invention will become apparent as this description progresses.

To the accomplishment of the above and related objects, this invention may be embodied in the form illustrated in the accompanying drawings, attention being

called to the fact, however, that the drawings are illustrative only, and that change may be made in the specific construction illustrated and described, so long as the scope of the appended claims is not violated.

In the drawings:

FIG. 1 is a perspective view, partially cut away, of my engine looking generally from one end of the output shaft;

FIG. 2 is an exploded perspective view of my engine looking generally at the opposite end of the output shaft and showing the rotary valve arrangement;

FIG. 3 is a perspective view of one of the pistons of my engine;

FIG. 3A is an exploded perspective view of the assembled piston shown in FIG. 3;

FIGS. 4–11 are diagrammatical views of a piston, the portion of the toroidal chamber in which the piston oscillates and the eccentric means which oscillates the piston; and

FIGS. 12–15 are diagrammatical views showing how oscillation of the four pistons in the toroidal chamber provide variable volume combustion chambers and indicating the firing sequence of the chambers.

Referring now to the drawings, it will be seen that my engine, indicated generally by the reference numeral **10**, comprises a frame, indicated generally by the reference numeral **12**, including a cylindrical shell **14** closed at its ends by end plates **16, 18** fastened to the shell by means such as the illustrated screws **20** which thread into the axially extending threaded openings **22** in the ends of the shell. Each of the end plates **16, 18** provide concentric center openings **28, 38** defining a rotational axis for my engine. A shaft **32** is concentrically mounted in these openings. The left-hand end (FIG. 1) of the shaft **32** is journal mounted on the end plate **18** by a bearing means **34** disposed in a concentric bearing sleeve **36** formed on the end plate while the right-hand end of the shaft (left-hand in FIG. 2) is journal mounted by means of a conventional bearing (not shown) disposed in the concentric opening **38** in the end plate **16**. This shaft **32** is the output shaft of the engine **10**.

In my illustrative and preferred embodiment, a rotor, indicated generally at **44**, is mounted on the shaft **32** for rotation therewith. As indicated previously, this rotor provides a toroidal chamber concentric with the axis of the shaft **32** and in which conformingly shaped pistons are disposed for oscillation about the axis relative to the rotor to define variable volume combustion chambers within the rotor. The illustrative rotor includes a cylindrical shell formed by three shell parts **46, 48, 50** with the part **48** being a divider between the said toroidal chamber and a gear compartment to be discussed hereinafter. The shell of the rotor is closed at its ends by end walls **52, 54**. The end wall **52** may be secured by means such as the illustrated screws **56** which thread into the openings **58** and the end wall **54** may be secured by means such as the illustrated screws **60** which thread into the openings **62**.

The rotor **44** also comprises a peripherally extending concentric inner wall **68** and a radially extending and concentric wall **70** in registry with the divider **48**. The inner surface of the shell part **46**, outer surface of the wall **68** and axially inwardly facing surfaces of the end walls **54, 70** define the said toroidal chamber.

A sun gear **74** is mounted to be concentric with the axis of the shaft **32** adjacent the chamber end wall **70**. The sun gear may be held fixed to the frame, for instance, by the concentric sleeve **76** through which the shaft extends, the sleeve **76** having a collar **77** attached to the end wall **18**. The left-hand end (FIG. 1) of the rotor **44** is journal mounted on this collar **77** by means such as the illustrated bearing **77***a*.

In the illustrative and preferred embodiment, the four pistons **78, 80, 82, 84** are driven, respectively, by planet gears **86, 88, 90, 92** which are meshed with the sun gear **74** and journal mounted on the rotor **44** to be driven when the rotor rotates about the sun gear. It will be seen that each planet gear **86, 88, 90, 92** is mounted on a shaft **94, 96, 98, 100** for rotation with the shaft. The end wall **70** of the toroidal chamber is provided with four peripherally spaced apart openings **102**, journal mounting the shafts **94, 96, 98, 100.**

The end wall **54** provides the four peripherally equally spaced, radially elongated ports **110, 112, 114, 116** providing communication into the four combustion chambers of the toroidal chamber. As seen in FIG. **2**, sealing rings **118** are disposed about these ports, the sealing rings being circular. The axially outer surface of the end wall **54** is provided with a concentric recess **122** which receives a concentric boss **124** on the end plate **16**. The axially inner surface of this boss **124** engages the sealing rings **118.** The end plate **16** is provided with an exhaust port **126** and an intake port **128**, each of which sequentially registers with the ports **110, 112, 114, 116** or, more particularly, with the circularly shaped sealing rings **118** about the ports in the end wall **54.** A conduit **130** leads away from the port **126** and another conduit **132** leads to the port **128.** It will be appreciated that this port structure just described constitutes a rotary valve system for admitting a fuel mixture to the variable volume combustion chambers and removing exhaust gases from these chambers. The illustrative and preferred embodiment of the present invention is a four-cycle engine and each of the said variable volume combustion chambers goes through its four cycles of intake, compression, ignition and exhaust during each revolution of the rotor **44.** The port **128** will register with each of the ports **110, 112, 114, 116** once during each revolution of the rotor at the time when the combustion chamber served by that port **110, 112, 114, 116** is in its intake cycle. Similarly, the exhaust port **126** will register with each port **110, 112, 114, 116** once each revolution at the time when the combustion chamber served by that port is in its exhaust cycle.

Finally, the end plate **16** is provided with a port **134** in which a spark plug **136** is disposed to be in registry with each of the ports **110, 112, 114, 116** once during each revolution of the rotor **44** at the time when the combustion chamber served by that port is in its ignition cycle.

The engine **10** of the present invention is, therefore, a four-cycle, four cylinder engine utilizing only one spark plug, only one intake port, and only one exhaust port.

The illustrated engine **10** is an air-cooled engine, but it will be appreciated that my basic engine may be liquid cooled if desired. In the illustrative embodiment, air intake openings **140** are formed in the end plate **18** and air outlet openings **142** are formed in the end plate **16.** It will be appreciated that there is a peripherally extending air space between the outer surface of the cylindrical shell of the rotor **44** and the inner surface of the shell **14**, this space being indicated at **144.** Fan

blades 146 are mounted on the end plate 52 of the rotor and arranged to draw air in the openings 140 and to force it out through the openings 142.

In FIG. 2, it will be seen that a concentric boss 150 on the end plate 54 is received in a mating concentric recess 152 in the boss 124.

Turning now to FIGS. 3 and 3A, the structure of the illustrated and preferred piston and eccentric drive will be discussed. The illustrative piston includes a shell 160 which is, of course, conformingly shaped to oscillate about the axis of the shaft 32. This shell 160 includes an axially extending bore 162 extending centrally through its main body portion, the axis of this bore lying in a radial plane halfway between the radially extending faces of the piston. A first cylindrical eccentric 164 is axially disposed in the bore 162 for rotation therein with the outer cylindrical surface of the eccentric 164 being in bearing engagement with the inner cylindrical surface of the bore 162. The first eccentric 164 has an axially extending second bore 166 extending therethrough, the axis for this bore 166 being parallel to and spaced apart from the cylinder axis of the eccentric 164. A second eccentric 168 is axially disposed in the bore 166 to be rotatable therein with its outer cylindrical surface being in bearing engagement with the inner cylindrical surface of the bore. The axial lengths of the bore 162, eccentric 164 and eccentric 168 are generally equal. The eccentric 168 is mounted on the shaft 94 for rotation therewith with the axis of the shaft 94 being parallel to and spaced apart from the cylinder axis of the eccentric 168. Aligned auxiliary shafts 170 extend axially outwardly from the opposite ends of the eccentric 168, the coinciding axes of these auxiliary shafts 170 being parallel to and spaced apart from the cylinder axis of the eccentric. The coinciding axes of the auxiliary shafts 170 lie in a plane which includes the cylinder axis of the eccentric 168 and the axis of the shaft 94. For reasons which will be clear as this description progresses, the distance between the coinciding axes of the shafts 170 and the cylinder axis of the eccentric 168 is exactly equal to the distance between the axis of the shaft 94 and the said cylinder axis. The auxiliary shafts 170 are drivers of the body of the piston and may or may not rotate about their axes. The shell 160 ends are closed by end plates 176, 178 which conformingly fit into cutouts formed respectively in the opposite ends of the piston. Seal grooves 180 are formed about the piston adjacent its front and rear surfaces and seal segments 182 are disposed in these grooves for reasons which will be well understood by those familiar with the engine arts. Similarly, oil grooves 184 are formed in the eccentrics 164, 168 and end plates 176, 178 so that lubricating oil may be fed to moving parts as required.

It will be seen that the axially inner surfaces of the end plates 176, 178 are formed with radially extending slots 190, the center lines of which lie in the said radial plane including the axis of the bore 162. The auxiliary shafts 170 extend into these slots 190 and drivingly engage the side walls of the slots. Of course, as the eccentric 168 rotates about the axis of the shaft 94, the shafts 170 move radially in the slots 190.

Further, the end plates 176, 178 are provided with arcuate elongated slots 192 through which the shaft 94 extends. It will be understood that the shaft 94 is journal mounted in an opening in the end wall 70 and another such opening in the end wall 54 to move with those end walls. The piston 78 must oscillate relative to those end walls about the axis of curvature of the elongated slots 92.

In recapitulation to this point, it will be seen that rotation of the rotor 44 relative to the sun gear 74 drives the planet gears 86, 88, 90, 92 and the shafts 94, 96, 98, 100 on which the planet gears are mounted. The eccentric means on these shafts respectively oscillate the pistons 78, 80, 82, 84 about the axis of the shaft 32 relative to the rotor 44.

The oscillatory movement of each piston is demonstrated in FIGS. 4–11 where the movement of the piston 78 relative to the shell 46 and inner wall 68 is illustrated. Marks 200–202 represent the starting point of the piston 78 relative to the shell 46. A radial plane, indicated by the center line 204, which includes the axis of the shaft 94 is centered between the marks 200, 202. It will be appreciated that in all views FIG. 4–FIG. 11, the axis of the shaft 94 is shown in this plane (center line 204). The movement counterclockwise of the eccentric 168 about the axis of the shaft 94 begins in FIG. 4 and progresses through FIG. 11. In FIG. 11, the eccentric 168 has moved approximately 330° from its starting position shown in FIG. 4. This counterclockwise movement of the eccentric 168 drives the eccentric 164 in a clockwise direction about the axis of the bore 162. The piston, therefore, must oscillate relative to the plane 204, i.e., the rotational axis of the shaft 94. It moves first counterclockwise to its maximum counterclockwise position shown in FIG. 6 and then back to its center position as shown in FIG. 8. It will be seen that, in FIG. 8, the eccentric 168 is 180° displaced from its position shown in FIG. 4. As the eccentric 168 continues to rotate counterclockwise about the axis of the shaft 94, the piston 78 must move clockwise from its centered position (FIG. 8) to its maximum displaced position shown in FIG. 10.

Turning now to FIGS. 12, 13, 14 and 15, it will be seen that the pistons 78 and 82 move together while the pistons 80, 84 move together. This is because the eccentric means for the pistons 78, 80 are in phase while the eccentric means for the pistons 80, 84 are in phase. Further, the eccentric means for the pistons 78, 82 are 180° out of phase with the eccentric means for the pistons 80, 84.

In FIGS. 12–15, I have used reference numerals 210, 212, 214, 216 to identify, respectively, the four variable volume combustion chambers defined by the four pistons 78, 80, 82, 84.

Assume that, in FIG. 12, chamber 210 is in its compression cycle, chamber 212 is in its intake cycle, chamber 214 is in its exhaust cycle and chamber 216 is in its ignition cycle. Progressing to FIG. 13, it will be seen that the compression cycle of chamber 210 is almost completed; that the intake cycle of the chamber 212 is almost completed; that the exhaust cycle of the chamber 214 is almost completed; and that the ignition cycle of the chamber 216 is almost completed. Progressing on to FIG. 14, it will be seen that these cycles in the respective chambers are completed or that the next cycle in the sequence is just beginning. For instance, in FIG. 14, the chamber 212 is just beginning its compression cycle after completing its intake cycle while the chamber 216 is just starting its exhaust cycle after completing its ignition cycle. In FIG. 15, the chamber 210 is shown after its ignition cycle has started and the chamber 214 is shown after its intake cycle has started.

Of course, the propelling force for the engine results from the explosion of gas in the chamber going through the ignition cycle, this explosion exerting great pressures against the pistons defining that chamber undergoing ignition causing them to separate.

In this description, and in the appended claims, the terms "sun gear" and "planet gears" are intended to apply generally to planet gear systems of the type including a main gear and secondary gears meshed with the main gear and revolvable about the main gear. In the drawings, the sun gear 74 and planet gears 86–92 are illustrated as being spur gears, but it will be appreciated that other types of gears might be used in a planetary gear system in accordance with my invention.

Further, it will be appreciated that various types of eccentric means other than that shown in FIGS. 3 and 3A may be used to cause oscillation of the pistons by the planet gears.

Still further, it will be appreciated that my disclosed engine, with modification, may be used as a steam engine, pump, compressor or fluid motor or similar machine.

What is claimed is:

1. An engine comprising a cylindrically shaped rotor, a support frame defining an axis for said rotor, a sun gear concentric with said axis, shaft means for journal mounting said rotor for concentric rotation about said axis on said frame and relative to said sun gear, said rotor providing a toroidal chamber concentric with said axis, conformingly shaped pistons disposed in said chamber for oscillatory movement about said axis relative to said rotor to define variable volume combustion chambers within said rotor, planet gears journal mounted on said rotor and meshed with said sun gear, and eccentric means drivingly connecting each said piston to one of said planet gears whereby relative rotation between said rotor and said sun gear about said axis produces oscillation of said piston relative to said rotor.

2. The engine of claim 1 in which there are four of said pistons defining four of said variable volume combustion chambers, said sun gear having a first diameter and a first number of teeth, each said planet gear having one-half the said first number of teeth and being one-half the said first diameter.

3. The engine of claim 1 in which said pistons include two pair of pistons defining four of said variable volume combustion chambers, the pistons of each pair being diametrically oppositely disposed, said sun gear having a first diameter and a first number of teeth, each said planet gear having one-half the said first number of teeth and being one-half the said first diameter.

4. The engine of claim 3 in which each piston is provided with a cylindrically-shaped bore, the axis of which is parallel to said first mentioned axis, and in which each eccentric means includes a first cylindrically-shaped eccentric axially disposed in said bore of its associated piston for rotation therein, said first eccentric having a second bore formed therein on an axis parallel to and spaced apart from the cylinder axis of said first eccentric, a second cylindrically shaped eccentric axially disposed in said second bore for rotation therein, and means for drivingly connecting said second eccentric to its associated planet gear.

5. The engine of claim 4 in which said means drivingly connecting said second eccentric to its associated planet gear includes a shaft driven by said planet gear, said second eccentric being mounted on said shaft for rotation therewith, the axis of said shaft being parallel to and spaced apart from the cylinder axis of said second eccentric.

6. The engine of claim 5 in which said planet gear is mounted on said shaft so that said shaft rotates with said planet gear.

7. The engine of claim 3 in which said eccentric means for each pair of pistons are in phase so that the pistons of each pair oscillate together relative to said rotor.

8. The engine of claim 7 in which said eccentric means for one of said pair of pistons is 180° out of phase with said eccentric means for the other pair of pistons whereby diametrically opposed combustion chambers are simultaneously at their maximum and minimum volumes.

9. The engine of claim 8 in which said rotor includes an end wall providing four equally peripherally spaced ports in communication with said toroidal chamber, said frame including a mating stationary end wall in sliding engagement with said rotor end wall, said stationary end wall providing an intake port and an exhaust port, each of said intake and exhaust ports being disposed sequentially to register with said four ports in said rotor end wall to supply a fuel mixture to and remove exhaust from said combustion chambers.

10. The engine of claim 9 in which said stationary end wall is provided with a third port disposed sequentially to register with said four ports, and a spark plug disposed in said third port sequentially to be exposed to said combustion chambers.

11. The engine of claim 5 in which said second eccentric includes a rigid auxiliary shaft extending axially from at least one end thereof, said auxiliary shaft being on an axis parallel to and spaced apart from the cylinder axis of said second eccentric and diametrically oppositely disposed from the axis of said shaft driven by said planet gear, said piston including an end plate closing the said cylindrically shaped bore formed therein, said end plate being formed with a radially elongated slot into which said auxiliary shaft extends for driving engagement, said auxiliary shaft being movable radially in said slot as said second eccentric rotates, said slot having a radial centerline passing through the axis of said bore in said piston.

12. The engine of claim 11 in which said end plate is formed with an arcuately elongated slot concentric with said rotor axis and through which extends said shaft driven by said planet gear.

13. An engine comprising a support frame defining a rotational axis, means providing a toroidal chamber concentric with said axis, a sun gear concentric with said axis, conformingly shaped pistons disposed in said chamber for oscillatory movement about said axis relative to said chamber to define, within said chamber, variable volume combustion chambers, planet gears meshed with said sun gear, and eccentric means drivingly connecting each said piston to one of said planet gears whereby rotation of said planet gear produces oscillation of said piston relative to said chamber, said planet gears being journal mounted on said means providing said toroidal chamber to be driven when there is relative rotation about said axis between said means and said sun gear, each piston being provided with a cylindrically-shaped bore, the axis of which is parallel to said first mentioned axis, and each eccentric means

including a first cylindrically-shaped eccentric axially disposed in said bore of its associated piston for rotation therein, said first eccentric having a second bore formed therein on an axis parallel to and spaced apart from the cylinder axis of said first eccentric, a second cylindrically-shaped eccentric axially disposed in said second bore for rotation therein, and means for drivingly connecting said second eccentric to its associated planet gear.

14. The engine of claim **13** in which said means drivingly connecting said second eccentric to its associated planet gear includes a shaft driven by said planet gear, said second eccentric being mounted on said shaft for rotation therewith, the axis of said shaft being parallel to and spaced apart from the cylinder axis of said second eccentric.

15. An engine comprising a support frame defining a rotational axis, means providing a toroidal chamber concentric with said axis, a sun gear concentric with said axis, conformingly shaped pistons disposed in said chamber for oscillatory movement about said axis relative to said chamber to define, within said chamber, variable volume combustion chambers, planet gears meshed with said sun gear, and eccentric means drivingly connecting each said piston to one of said planet gears whereby rotation of said planet gear produces oscillation of said piston relative to said chamber, said planet gears being journal mounted on said means providing said toroidal chamber to be driven when there is relative rotation about said axis between said means and said sun gear, said pistons including two pair of pistons defining four of said variable volume combustion chambers, the pistons of each pair being diametrically oppositely disposed, said sun gear having a first diameter and a first number of teeth, each said planet gear having one-half the said first number of teeth and being one-half the said first diameter.

16. The engine of claim **15** in which said eccentric means for each pair of pistons are in phase so that the pistons of each pair oscillate together about said axis.

17. The engine of claim **16** in which said eccentric means for one of said pair of pistons is 180° out of phase with said eccentric means for the other pair of pistons whereby diametrically opposed combustion chambers are simultaneously at their maximum and minimum volumes.

18. The engine of claim **17** in which said means defining said toroidal chamber includes a rotor rotatable relative to said sun gear, said rotor including an end wall providing four equally peripherally spaced ports in communication with said toroidal chamber, said frame including a mating stationary end wall in sliding engagement with said rotor end wall, said stationary end wall providing an intake port and an exhaust port, each of said intake and exhaust ports being disposed sequentially to register with said four ports in said rotor end wall to supply a fuel mixture to and remove exhaust from said combustion chambers.

19. The engine of claim **18** in which said stationary end wall is provided with a third port disposed sequentially to register with said four ports, and a spark plug disposed in said third port sequentially to be exposed to said combustion chambers.

20. The engine of claim **14** in which said second eccentric includes a rigid auxiliary shaft extending axially from at least one end thereof, said auxiliary shaft being on an axis parallel to and spaced apart from the cylinder axis of said second eccentric and diametrically oppositely disposed from the axis of said shaft driven by said planet gear, said piston including an end plate closing the said cylindrically shaped bore formed therein, said end plate being formed with a radially elongated slot into which said auxiliary shaft extends for driving engagement, said auxiliary shaft being movable radially in said slot as said second eccentric rotates, said slot having a radial centerline passing through the axis of said bore in said piston.

21. The engine of claim **20** in which said end plate is formed with an arcuately elongated slot concentric with said rotor axis and through which extends said shaft driven by said planet gear.

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