United States Patent [19]

Harrington

[11] **3,858,560**

[45] **Jan. 7, 1975**

[54] **RECIPROCATING ROTARY ENGINE**

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[73] Assignee: **General Motors Corporation,** Detroit, Mich.

[22] Filed: **Nov. 26, 1973**

[21] Appl. No.: **419,035**

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

[51] **Int. Cl.** **F02b 53/00**

[58] **Field of Search** 123/8.47; 418/33, 36, 37

[56] **References Cited**

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Assistant Examiner—Michael Koczo, Jr.
Attorney, Agent, or Firm—Charles R. Engle

[57] **ABSTRACT**

A rotary machine of the oscillating vane type including a shaft having a pair of vane assemblies rotatably mounted on the shaft and being driven for oscillating rotation relative to each other to provide intake, compression, expansion and exhaust cycles during each revolution. The vane assemblies have respective power transmitting plates secured thereto, each plate having a radially extending slot respectively receiving a drive pin secured to a power transmitting chain. The chain engages freely rotatable pinion gears and a power transmitting gear on a centrally located output shaft thereby providing a driving connection between the vanes and the shaft.

6 Claims, 14 Drawing Figures

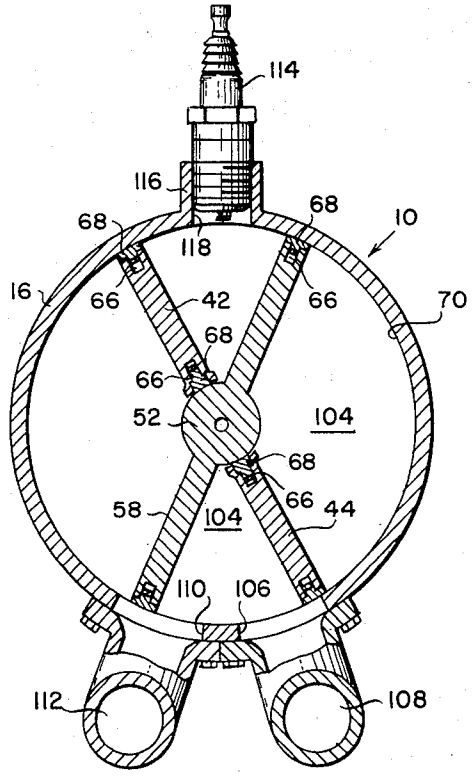


Fig. 1

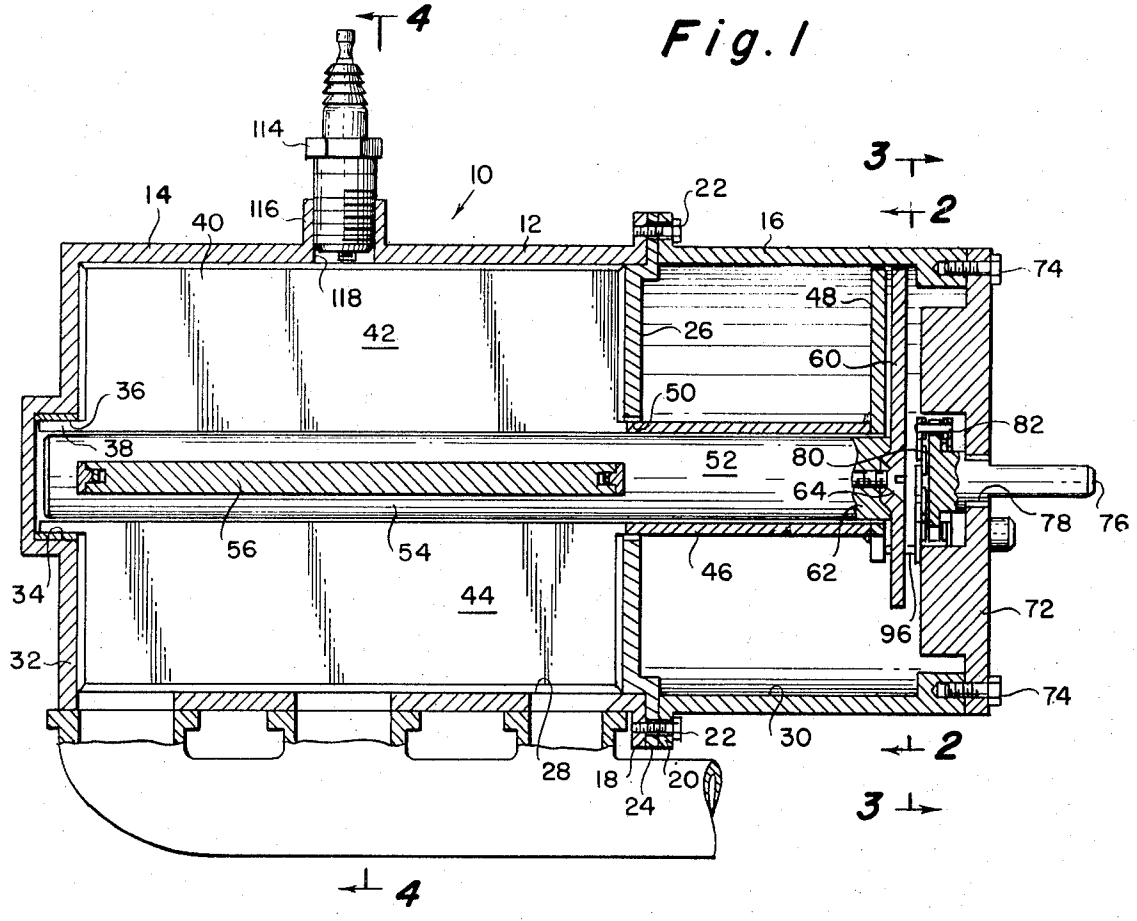


Fig. 2

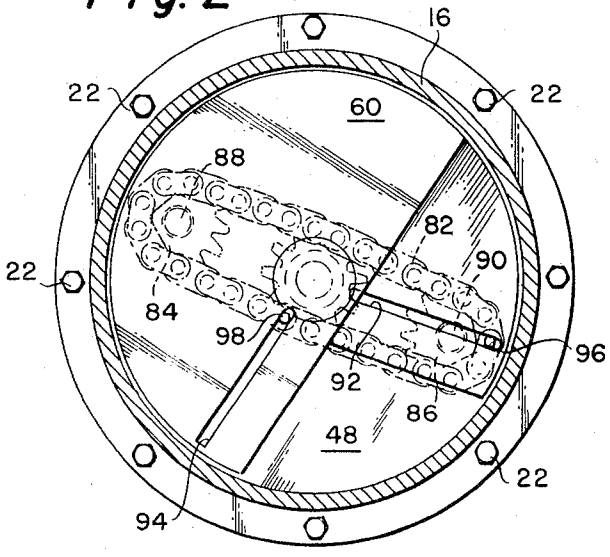


Fig. 3

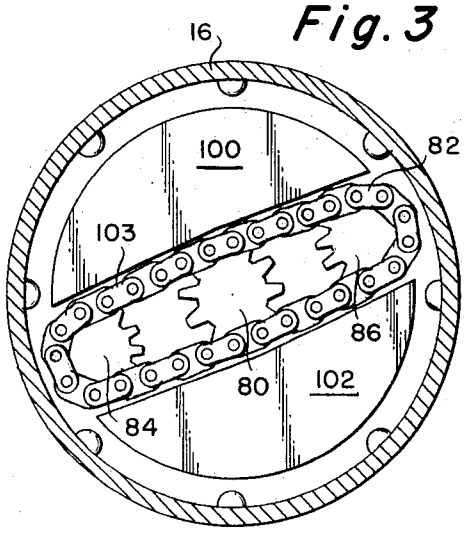
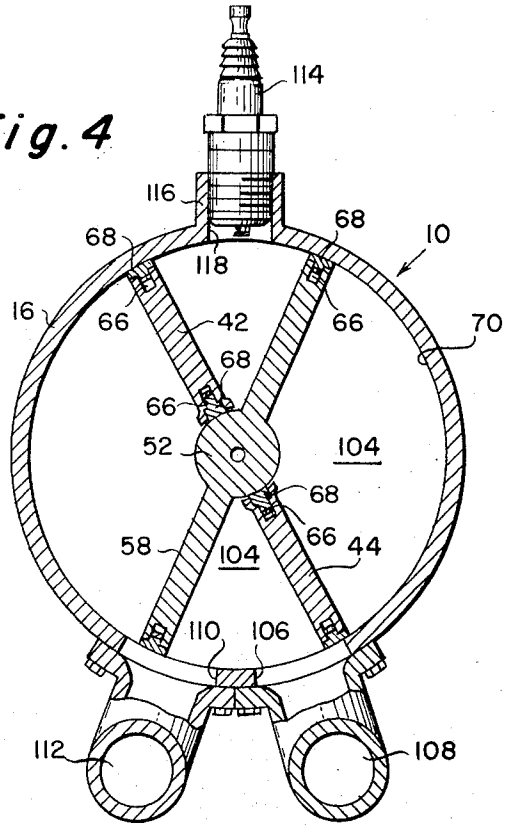


Fig. 4



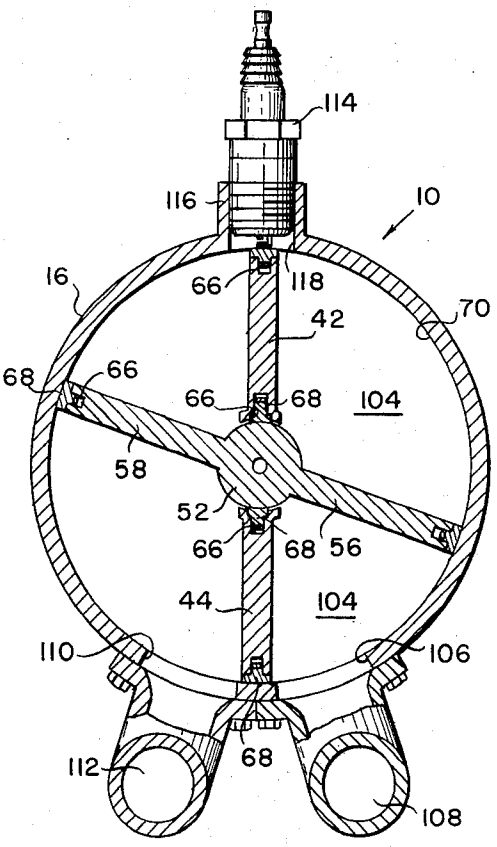


Fig. 5

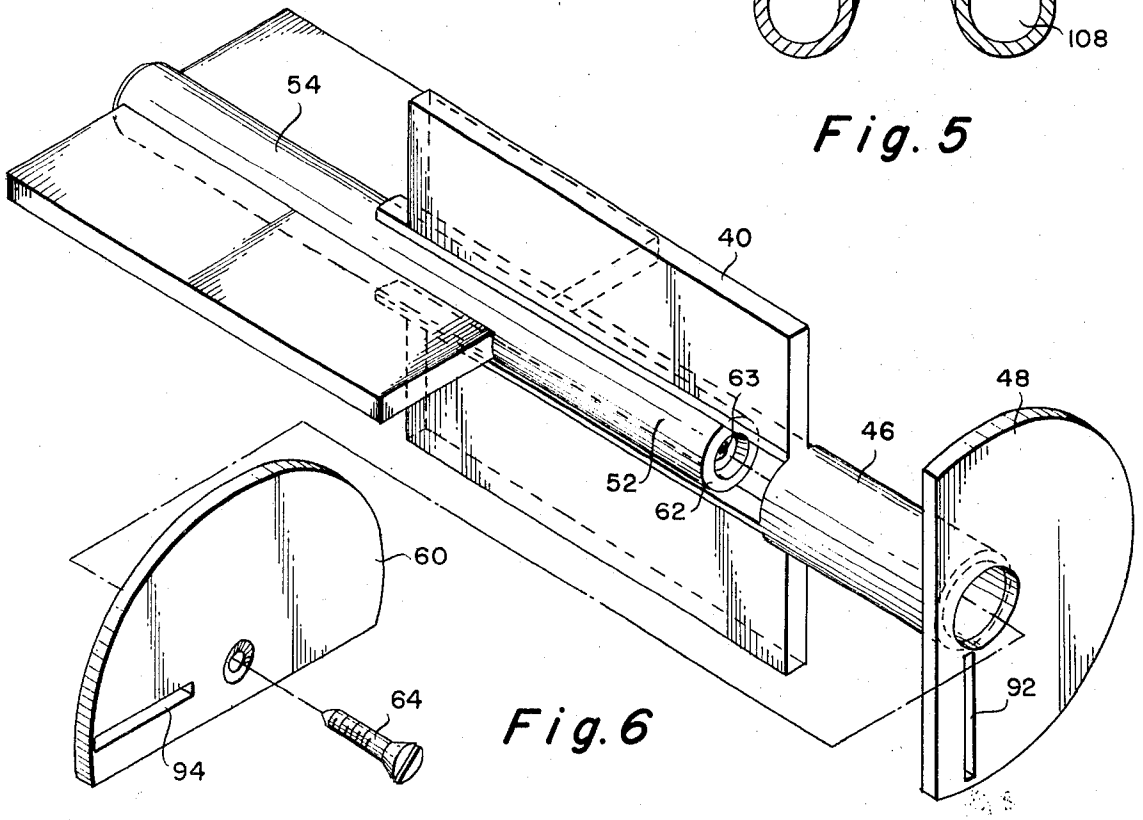


Fig. 6

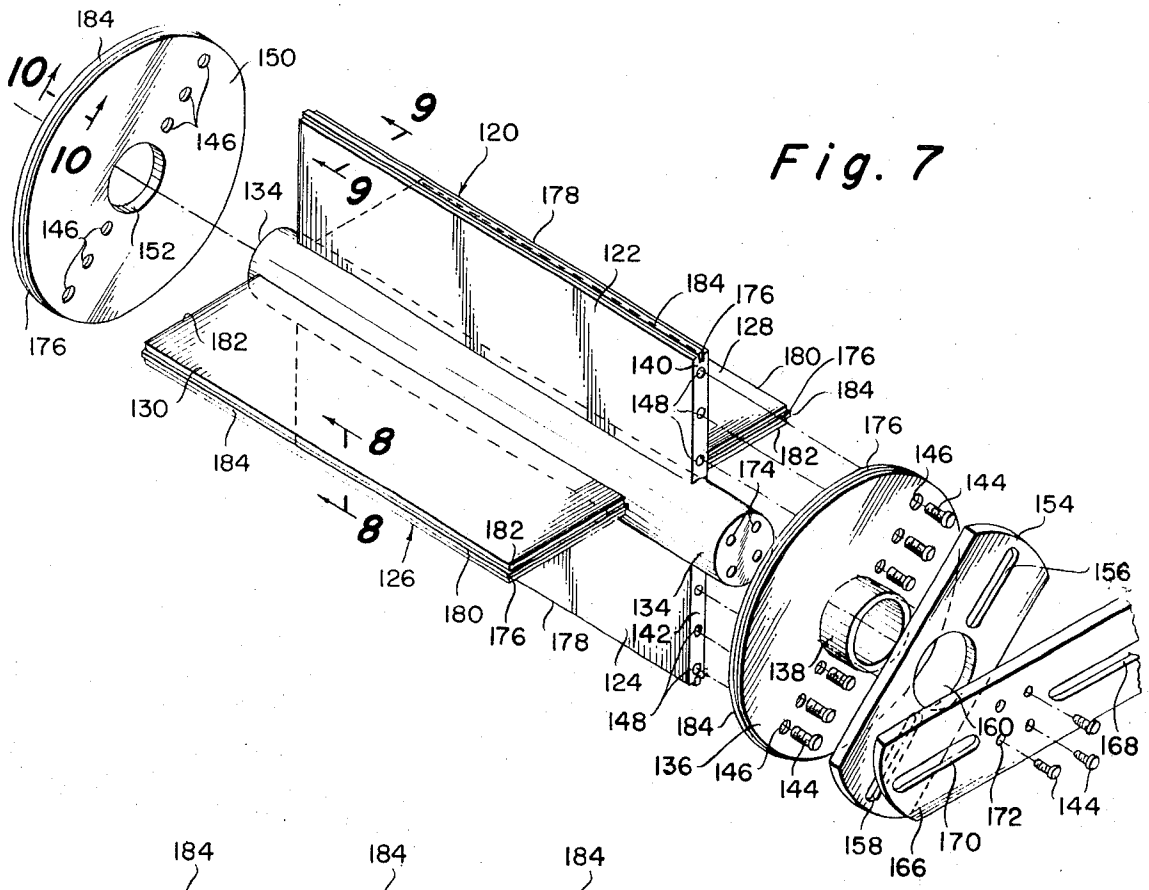


Fig. 7

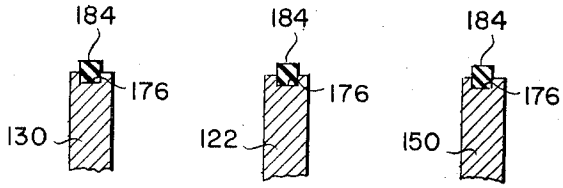


Fig. 8 Fig. 9 Fig. 10

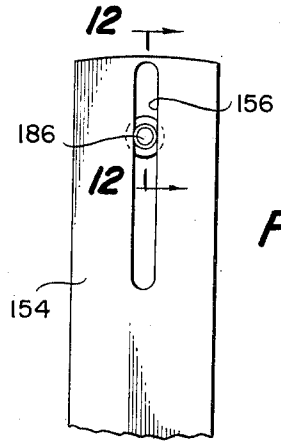


Fig. 11

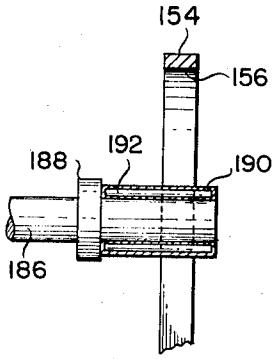


Fig. 12

Fig. 13

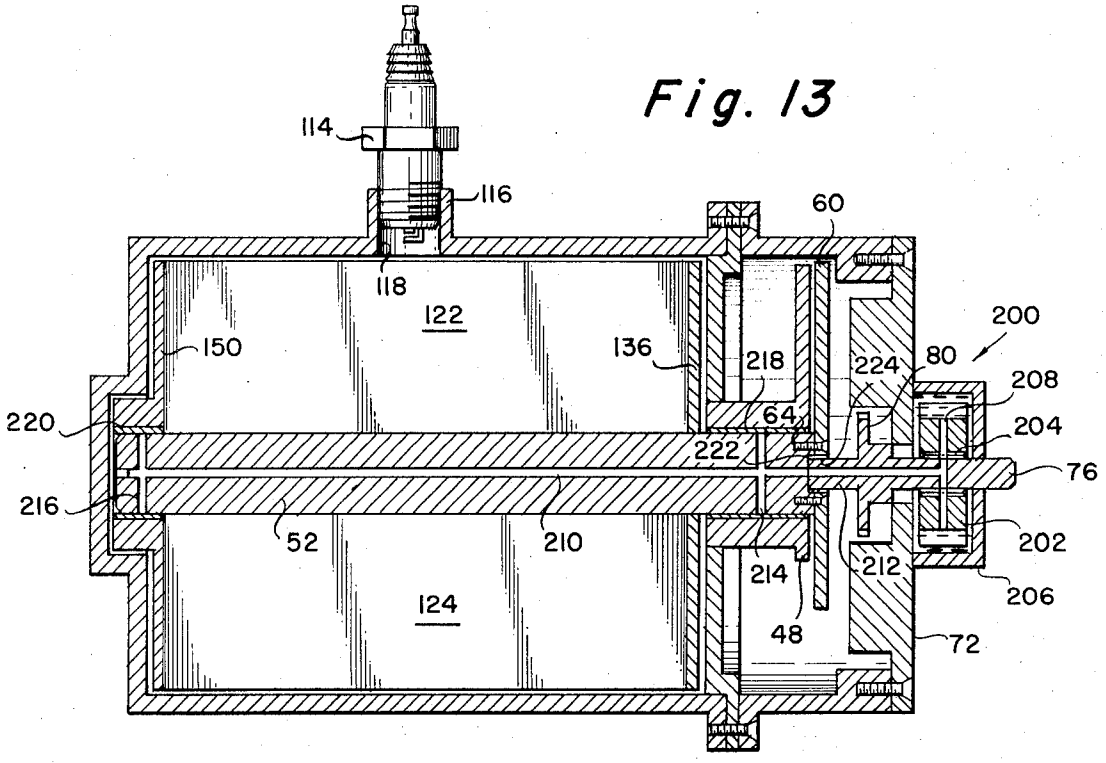
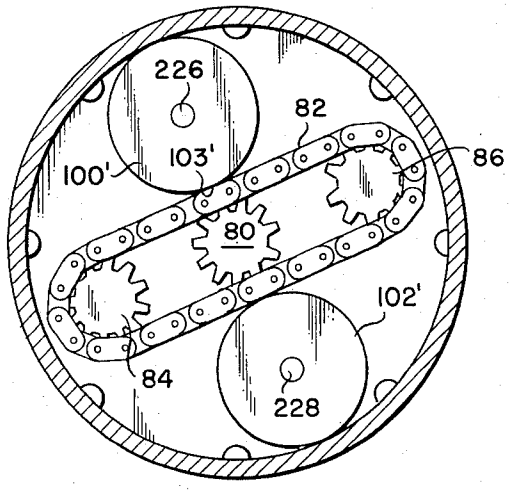

114
116
118
60
122
150
136
218
224
80
200
208
64
204
220
222
76
216
52
210
214
212
202
206
124
48
72

Fig. 14


226
82
86
100'
103'
80
102'
84
228

RECIPROCATING ROTARY ENGINE

This invention relates to a rotary machine of the oscillating vane type wherein the vanes approach and recede from one another during rotation thereof and more specifically to an improved mechanism for providing the varying relative rotational velocity of the vanes necessary to provide intake, compression, expansion, and exhaust cycles during a complete revolution of each vanes.

Rotary machines incorporating vane assemblies having varying relative velocities during rotation of the vanes are common in the rotary machine art. Necessarily the mechanisms utilized to change the speed of rotation of one vane relative to another to provide oscillating movement therebetween producing an intake, compression, expansion, and exhaust cycle during each revolution are somewhat complex. Therefore, it is a purpose of this invention to provide an improved drive mechanism for a rotary machine employing oscillating vanes therein. The improved mechanism of my invention includes concentrically mounting of a first vane assembly upon a shaft supporting a second vane assembly so that the vane assemblies are rotatable relative to one another. A drive plate in the form of a segment of a circle containing a radially extending slot at a predetermined location is secured to each vane assembly. A drive gear, connected to an output shaft, is attached to a housing end plate adjacent the drive plates and is driven by an endless chain engaging two pinion gears also rotatably mounted on the end plate. To chain link connecting pins are modified to form a drive pin extending a sufficient distance laterally of the chain so as to engage the slots in the drive plates providing a driving connection therebetween. One of the modified pins engages a respective slot in the drive plates so that each vanve set is driven in a spaced relationship by the particular modified drive pin secured to the chain. In this manner, as the chain traverses the pinion gears and the drive gear, the velocity of one vane assembly varies relative to the velocity of the other vane assembly as determined by the position of the drive pins in the chain. The drive slots and chain pins are positioned so that as two of the vanes approach top dead center of the machine the gases therebetween are compressed. In the case of an internal combustion engine, the compressed fuel-air mixture would be ignited for the engine power stroke. Upon firing of the spark plug or upon further rotation of the shaft, the leading vane is caused to leave the trailing vane during an expansion cycle and the trailing vane then rotates to engage an exhaust port completing an exhaust cycle just prior to bottom dead center. The leading vane then passes an intake port slightly pass bottom dead center and the trailing vane then closes off the inlet port completing an inlet cycle. The velocity of the trailing vane then increases and rapidly approaches the leading vane compressing the gases between the two vanes completing the compressing cycle again in the area of top dead center where the compressed gases are either ignited or discharged into a pressure fluid system.

It is obvious that this machine can be used as a pump, compressor, or an internal combustion engine. In the case of an internal combustion engine, the mixture is compressed at top dead center and ignited so as to rapidly move the leading vane away from the trailing vane during the expansion cycle and the trailing vane then completes the exhaust cycle when it closes off the exhaust port just prior to bottom dead center. In this manner, the output shaft is rotated through the pin connections in the drive plate slots as the drive plates cause the pins to drive the chain on the pinions and the drive gear. Should the machine be used as a pump or a compressor, the output shaft becomes an input shaft and is driven externally supplying power into the machine through the shaft drive gear and consequently to the vanes through the chain, drive pins and drive plates. In other words, the drive arrangement would be the reverse of that of an internal combustion engine when the machine is being used as a compressor or pump.

Accordingly, a prime object of my invention is the provision of a simplified means of drivingly connecting a plurality of vane assemblies in a rotary machine to a drive shaft.

Another object of my invention is the provision of drive plates secured to respective vane set assemblies in a rotary machine wherein the drive plates contain radially extending slots engaged by drive means connected with a drive shaft so that the vanes have a predetermined varying relative rotational velocity as they complete each revolution within the rotary machine so as to provide intake, compression, expansion, and exhaust cycles.

A further object of my invention is the provision of concentrically relatively rotatable vane sets each set being connected to a drive plate having a slot therein, a power transmitting endless chain mounted upon gears secured to a housing end plate adjacent the drive plates, a power transmitting shaft connected to one of the gears and driving pins in the chain engaging the drive plate slots providing a driving connection between the vane sets and the power transmitting shaft.

The novel features which I believe to be characteristic of my invention are set forth with particularlity in the appended claims. My invention itself, however, both as to its organization and method of operation, may be best understood by reference to the following description taken in connection with the accompanying drawings in which:

FIG. 1 is an elevational view partly in section illustrating the rotary machine of the present invention.

FIG. 2 is a sectional view taken on line 2—2 of FIG. 1 as viewed in the direction indicated.

FIG. 3 is a sectional view taken on line 3—3 of FIG. 1 as viewed in the direction indicated.

FIG. 4 is a sectional view taken on line 4—4 of FIG. 1.

FIG. 5 is also a sectional view taken on line 4—4 of FIG. 1 but illustrating the machine vanes in a rotated position.

FIG. 6 is a perspective exploded view illustrating vane assemblies of the subject invention.

FIG. 7 is a perspective exploded view illustrating a modified form of the vane assemblies of the subject invention.

FIG. 8 is an enlarged fragmentary sectional view taken on line 8—8 of FIG. 7.

FIG. 9 is an enlarged fragmentary sectional view taken on line 9—9 of FIG. 7.

FIG. 10 is an enlarged fragmentary sectional view taken on line 10—10 of FIG. 7.

FIG. 11 is a partial plan view showing one of the drive plates of my invention.

FIG. 12 is an enlarged fragmentary sectional view taken on line 12—12 of FIG. 11.

FIG. 13 is a sectional view of a modified form of my invention.

FIG. 14 is an end sectional view of a modified form of my invention.

Referring now to FIG. 1, a rotary machine 10 includes a casing 12 composed of a power section housing 14 and a drive section housing 16. The power section housing 14 is connected to the drive section housing 16 by virtue of mating flanges 18 and 20 secured together by a plurality of machine screws 22. The flanges 18 and 20 receive a flange 24 therebetween which is integral with intermediate plate 26 dividing a power working chamber 28 from an accessory or drive chamber 30 formed by their respective housings 14 and 16. The chamber 30 can mount an engine oil pump and other required accessories. The process chamber 28 is enclosed by an end plate 32 containing a recess 34 having a sleeve bearing 36 therein rotatably supporting an annular flange 38 integral with a first vane set 40. The first vane set 40 includes diametrically oppositely disposed vanes 42 and 44 which are integral with a cylindrical sleeve 46 that is in turn secured to a drive member in the form of a circular plate 48. The cylindrical sleeve 46 is rotatable supported in the intermediate plate 26 on a cylindrical sleeve bearing 50.

The first vane set 40 and the cylindrical sleeve 46 are concentrically and rotatably disposed upon a solid shaft member 52. The shaft 52 is an integral part of a second vane set 54 including diametrically oppositely disposed vanes 56 and 58. The shaft 52 also has a drive member in the form of a circular plate 60 secured to end 62 by a machine screw 64 providing a dividing connection therebetween. As shown in FIG. 4, the respective vanes 42, 44, 56 and 58 each contain axially extending slots 66 receiving a spring biased seal assembly 68 providing fluid tight engagement between the seals 68 and the inner peripheral surface 70 of housing 14 and shaft 52.

With reference again to FIG. 1, the drive housing 16 is enclosed by an end plate 72 which is secured thereto by a plurality of machine screws 74. An output shaft 76 is rotatably mounted in the end plate 72 and is supported by a press-fit sleeve bearing 78. A drive gear or sprocket 80 is integral with the output shaft 76 or is fixedly attached thereto for drivingly engaging a chain 82. As best illustrated in FIGS. 2 and 3, the chain 82 passes around a pair of pinion gears or sprockets 84 and 86 which are rotatably mounted upon respective stub shafts 88 and 90 secured to end plate 72. The chain 82 is an endless chain providing a driving connection between the sprockets 84 and 86 and the sprocket 80.

The circular drive plates 48 and 60 are disposed adjacent end plate 72 and contain substantially radially extending slots 92 and 94. The endless chain 82 includes two extended connecting pins 96 and 98 which respectively extend into slots 92 and 94 and in this manner drivingly engage plates 48 and 60. By virtue of the engagement of the pins 96 and 98 with the drive plates 48 and 60 in their respective slots 92 and 94, a driving connection is provided between the first vane set 40 and output shaft 76 via drive plate 48, connecting pin 96 in slot 92, and sprocket 80. Likewise, a driving connecting is provided between the second vane set 54 and drive plate 60 via pin 98 in slot 94 through endless chain 82 and gear 80 to the output shaft 76.

Referring now to FIG. 3, the endless chain 82 is shown in engagement with drive gear 80 and pinions 84 and 86 providing for continuous rotary movement of the chain on the respective gears. In order to ensure engagement of the chain 82 with the respective gears, a pair of chain guides 100 and 102 are provided on end plate 72 forming a channel 103 confining the path of movement of the chain 82, as illustrated.

With reference to FIGS. 4 and 5, the rotary machine of my invention is shown in the form of an internal combustion engine. The power section housing 14 defines in conjunction with the vanes of the respective vane sets 40 and 54 a plurality of working chambers 104 as the vanes rotate therein. The power housing 14 is modified to include an exhaust opening 106 which connects with an exhaust manifold 108 and to include an intake opening 110 that is connected to an intake manifold 112. In a diametrically opposed position in the housing 14, a spark plug 114 is secured in a threaded upstanding flange 116 in alignment with a firing aperture 118. The aforementioned drive connection between the respective vane sets 40 and 54 via the drive plates 48 and 60, pins 96 and 98 in slots 92 and 94, and output shaft 76 results in a cat and mouse type of oscillation between adjacent vanes of the respective vane sets. More specifically, as shown in FIG. 4, vanes 42 and 56 of the first and second vane sets 40 and 54 are illustrated at a fuel mixture compressed position for combustion via an electrical pulse through spark plug 114. With reference to FIG. 5, upon combustion vane 56 rapidly moves during its power stroke while vane 42 has moves a lesser distance relative to vane 56. The movement of vane 56 during its power stroke rapidly brings vane 58 close to vane 42 for a subsequent power stroke on vane 42. The rapid movement of vane 42 relative to vane 58 brings vane 44 close to vane 58 compressing another fuel-air mixture adjacent spark plug 114. In this manner the engine fires four times during each complete revolution of the vanes. The exhaust gases are swept through manifold 108 and a new charge is drawn in through manifold 112 as the respective vanes rotate past exhaust outlet 106 and inlet opening 110.

The concentric disposition of the respective vane sets is best illustrated in FIG. 6. In this figure, the vane set 40 is shown partially removed from the second vane set 54 and illustrates the integral connection of drive plate 48 on sleeve 46. With respect to the second vane set 54, the shaft 52 is shown with its end 62 containing a tapped hole 63 for receipt of machine screw 64 utilized to secure drive plate 60 thereto. It is apparent the vane sets can rotate relative to one another and that they can be independently driven through slots 92 and 94 in the drive plates.

A modified and improved form of my invention is shown in FIG. 7 wherein a first vane set 120 including vanes 122 and 124 is rotatably mounted upon a second vane set 126 which includes vanes 128 and 130. A first circular reinforcing plate 136 including an integral sleeve 138 is secured to lateral edges 140 and 142 of vanes 122 and 124 by threaded screws 144 passing through aperture 146 and engaging tapped holes 148 in the vanes. A second circular reinforcing plate 150 likewise contains fastening screw apertures 146 and also contains a centrally located aperture 152 fitting upon shaft 134 and providing a bearing surface for the other end of the vane set 120 thereon. Of course it is neces-

sary to provide suitable bearing supports, not shown, on the shafts **52** and **134** illustrated in FIGS. **1** and **7**, respectively, for adequate rotational support of the vane assemblies **120** and **126** as well as for plate **136**, sleeve **138** and plate **150**.

A first drive plate **154** contains diametrically opposed radially extending drive slots **156** and **158** as well as a central mounting aperture **160** which is fastened to sleeve **138** of reinforcing plate **136** in the same manner as sleeve **46** is secured to plate **48** in FIG. **1**. A second drive plate **166** also contains opposed drive slots **168** and **170** and has a series of substantially centrally located apertures **172** receiving screws **144** which engage tapped holes **174** in the end of shaft **134**. The vanes **122** and **124** contain a seal groove **176** along their axial edges **178** while the reinforcing plates **136** and **150** contain a like circumferential groove **176**. The vanes **128** and **130** also include seal groove **176**, which extends along their axial edges **180** and also along their lateral edges **182**. The grooves **176** receive a seal **184** as best shown in FIGS. **8**, **9** and **10**. When the vane sets are assembled, the seals **176** in the plates **136** and **150** and the seals in the axial edges **178** and **180** of vanes **122**, **124**, **128** and **130** engage inner peripheral surface **70** of housing **14** as shown in FIG. **4**. The seals **184** in lateral edges **182** of vanes **128** and **130** engage the plates **136** and **150** providing a completely sealed assembly.

With reference now to FIGS. **11** and **12**, extended chain link pins **186** are modified to include a circumferential flange **188** positioning a roller **190** upon a plurality of needle bearings **192** as is best illustrated in FIG. **12**. Of course, the provision of the rollers **190** for rotatable engagement with the edges of the drive plate slots **156**, **158**, **168** and **170** during operation of the rotary machine, greatly reduces friction in the driving connection. As shown in FIG. **13**, a positive displacement gear type oil pump assembly **200** can be secured to housing end plate **72**. The oil pump is driven by output shaft **76** through a drive gear **202** drivingly connected to the shaft by a spline connection **204**. Of course, the gear **202** can be connected to the shaft by any conventional means. The drive gear **202** rotates in pump housing **206** engaging a driven gear and pressurizing the oil therein in a manner as is well known in the pump art. The pressurized oil is forced through a laterally extending passage **208** in the gear **202** and flows through an axial passage **210** extending through output shaft **76**, drive gear **80**, gear extension **212** and shaft **52**. The passage **210** connects with lateral passages **214** and **216** lubricating sleeve bearings **218** and **220** as shown. The shaft **52** can contain as many lateral passages as necessary to properly lubricate its supporting bearings. The lubrication system can be a forced type maintaining a specified oil pressure in the system or it can be a recirculating system including return passages and a sump, not shown. If the lubrication system is such that no oil is supplied to the power chamber **28**, this section could be lubricated by adding a metered amount of oil to the fuel charge.

The drive sprocket **80** is also modified in this configuration of my engine by including the extension or projection **212** which is rotatably received in a sleeve bearing **222** rotatably supporting it in a cavity **224** in the end of shaft **52**. This additional support of the sprocket **80** provides for stability during operation of the machine. In this form of my rotary machine, the drive plate **60** is secured to shaft **52** by a plurality of circumferentially spaced machine screws **64**.

With reference now to FIG. **14**, a further modification of my rotary machine is shown. The fixed chain guides **100** and **102** forming a channel **103** have been replaced with idler wheels **100'** and **102'** rotatably mounted on stub shafts **226** and **228** secured to end plate **72**. The idler wheels form a channel **103'** limiting movement of the chain **82** away from drive sprocket **80** by which they are effective to retain the chain **82** on gear **80** while adding a minimum of operational friction into the driving connection.

While I have described my rotary machine as an internal combustion engine in order to provide an output of power to shaft **76** through the endless chain **82** and the driving pins **96** and **98** it is, of course apparent this machine could be used as a compressor. In other words, a power source could be drivingly connected to shaft **76** so that there is an input of power through the chain **82** and pins **96** and **98** to the vane sets **40** and **54** to compress fluid within the working chambers **104** for discharge through a suitable manifolding arrangement. It is understood, of course, that various other modifications and alternative constructions may be made without departing from the true spirit and scope of my invention and that I intend by the appended claims to cover all such modifications and alternative constructions.

I claim:

1. A rotary machine of the oscillating vane type having a housing defining a working chamber; a first vane assembly rotatably mounted in said worker chamber; a first drive member secured to said first vane assembly; a second vane assembly rotatably mounted in said working chamber; a second drive member secured to said second vane assembly adjacent said first drive member; each of said drive members having a driving connection slot therein; an end housing member enclosing said housing; said drive members being positioned adjacent said end housing member; a shaft rotatably journalled in said end housing member; a sprocket secured to said shaft within said housing; a pair of idler sprockets rotatably mounted on said end housing member within said housing and in spaced relation to said shaft sprocket; an endless chain disposed upon said sprockets for movement thereon; a first extended connecting pin in said chain engaging the slot in said first drive member and a second extended connecting pin in said chain engaging the slot in said second drive member whereby said first and second vane assemblies rotate and oscillate relative to one another at varying speeds causing adjacent vanes to approach and recede from each other thereby providing inlet, compression, expansion and exhaust cycles during each revolution of said vane assemblies.

2. A rotary machine of the oscillating vane type having a housing defining a working chamber; a first vane assembly rotatably mounted in said working chamber; a first drive plate secured to said first vane assembly; a second vane assembly concentrically disposed upon said first vane assembly and rotatably mounted within said working chamber, said second vane assembly being rotatable relative to said first vane assembly; a second drive plate secured to said second vane assembly adjacent said first drive plate, each of said drive plates having a radially extending slot therein in a predetermined position, an end plate enclosing said hous-

ing, said drive plates being positioned adjacent said end plate; a shaft rotatably journalled in said end plate; a sprocket secured to said shaft within said housing; a pair of idler sprockets rotatably mounted on said end plate within said housing and in spaced relation to said shaft sprocket; an endless chain disposed upon said sprockets for movement thereon; a first chain link extended connecting pin in said chain engaging the slot in said first drive plate; and a second chain link extended connecting pin in said chain engaging the slot in said second drive member whereby said first and second vane assemblies rotate and oscillate relative to one another at varying speeds causing adjacent vanes to approach and recede from each other in a timed relationship as determined by the extended connecting pins moving in their respective slots of the drive plates thereby providing inlet, compression, expansion and exhaust cycles during each revolution of said vane assemblies.

3. A rotary internal combustion engine of the oscillating vane type having a housing defining a working chamber and a drive chamber; an intermediate wall in said housing separating said working chamber from said drive chamber; a first vane assembly rotatably mounted in said working chamber; a first drive plate secured to said first vane assembly for rotation within said drive chamber; a second vane assembly concentrically positioned relative to said first vane assembly and rotatable relative thereto; a second drive plate secured to said second vane assembly adjacent said first plate within the drive chamber; each of said drive plates having a radially extending driving connection slot therein; an end plate secured to said housing enclosing said drive chamber; said drive plates being positioned adjacent said end plate; an output shaft rotatably journalled in said end plate; said end plate having a slot facing said drive plates and extending laterally to the axis of said output shaft; a drive sprocket secured to said output shaft within said lateral slot; a pair of idler sprockets rotatably mounted on said end plate within said slot in spaced relation to said shaft sprocket; an endless chain disposed upon said sprockets for movement thereon; a first chain link extended connecting pin engaging the drive slot in said first drive plate; and a second chain link extended connecting pin engaging the slot in said second drive plate whereby said first and second vane assemblies rotate and oscillate relative to one another at varying speeds as a compressed fuel-air mixture is ignited therebetween causing adjacent vanes to approach and recede from each other as a result of the connecting pins drivingly engaging their respective slots in the drive plates thereby providing inlet, compression, expansion and exhaust cycles during each revolution of said vane assemblies.

4. A rotary internal combustion engine of the oscillating vane type having a housing defining a working chamber and a drive chamber; an intermediate wall in said housing separating said working chamber from said drive chamber; a first vane assembly rotatably mounted in said working chamber and having integral drive means extending into said drive chamber; a first drive plate secured to said first integral drive means; a second vane assembly concentrically positioned upon said first vane assembly for rotation relative thereto and having integral drive means extending into said drive chamber; a second drive plate secured to said second vane assembly drive means; said second drive plate being positioned adjacent said first drive plate within said drive chamber; each of said drive plates containing a radially extending driving connection slot therein; an end plate secured to said housing enclosing said drive chamber; both of said drive plates being adjacent the interior surface of said end plate; an output shaft rotatably journalled in said end plate; said end plate containing a slot in its inner surface extending diametrically laterally to the axis of said output shaft; a drive sprocket secured to said output shaft within said lateral slot; a pair of idler sprockets rotatably mounted on said end plate on either side of said drive sprocket within said slot in spaced relation to said shaft sprocket; an endless chain disposed upon said sprockets for movement thereon; a first chain link extended connecting pin positioned in the drive slot of said first drive plate for sliding engagement therewith; a second chain link extended connecting pin positioned in the slot of said second drive plate for sliding engagement therewith; a spark plug located in said housing mounted in said housing at a top dead center position; an exhaust manifold connected to said engine housing for communication with said working chamber therein at a position on the leading side of bottom dead center of the engine housing; and an intake manifold connected to said housing at a position immediately trailing bottom dead center of the housing whereby said first and second vane assemblies rotate and oscillate relative to one another at varying speeds by virtue of the chain link connecting pins engaging the respective drive slots in the drive plate so that as compressed fuel-air mixtures are ignited when compressed adjacent said spark plug, adjacent vanes of the first and second vane assemblies approach and recede from each other thereby providing inlet, compression, expansion and exhaust cycles during each revolution of said chain assemblies.

5. A rotary internal combustion engine of the oscillating vane type having a housing defining a working chamber and a drive chamber; an intermediate wall in said housing separating said working chamber from said drive chamber; a first vane assembly rotatably mounted in said working chamber; each vane in said first vane assembly having a groove in the edge peripheral surfaces thereof; a fluid seal in said groove extending along the lateral edges and the axial edge of each of said vane; a second vane assembly concentrically positioned relative to said first vane assembly and rotatable relative thereto; a groove in the axial edge of each vane in said second vane assembly; a seal in said grooves engaging said housing; a reinforcing plate secured to the laterally extending edges of the vanes in said second vane assembly at each end thereof; a first drive plate secured to said first vane assembly for rotation within said drive chamber; a second drive plate secured to said second vane assembly adjacent said first plate; each of said drive plates having diametrically opposed radially extending driving connection slots therein; an end plate secured to said housing enclosing said drive chamber; said drive plates being positioned adjacent said end plate; an output shaft rotatably journalled in said end plate; a drive sprocket secured to said output shaft; a pair of idler sprockets rotatably mounted on said end plate in spaced relation to said shaft sprocket; an endless chain disposed upon said sprockets for movement thereon; a first pair of extended chain link connecting pins having driving rollers rotatably mounted thereon; said rollers engaging the

slots in said first drive plate providing a driving connection to said first vane set and a second pair of extended chain link connecting pins having rollers rotatably mounted thereon; said rollers engaging the slots in said second drive plate providing a driving connection to said second vane set.

6. A rotary machine of the oscillating vane type having a housing defining a working chamber; a first vane assembly rotatably mounted in said working chamber; a first drive member secured to said first vane assembly; a second vane assembly rotatably mounted in said working chamber concentrically upon said first vane assembly; a second drive member secured to said second vane assembly adjacent said first drive member; said first vane assembly including a shaft rotatably mounted in said housing and rotatably supporting said second vane assembly; each of said drive members having a driving connection slot therein; an end housing member enclosing said housing; said drive members being positioned adjacent said end housing member; an output shaft rotatably journalled in said end housing member; an oil pump assembly secured to said end housing member and being driven by said output shaft; said shaft of said first vane assembly having an axial lubricating passage therein connecting with lateral passages in said shaft at predetermined locations lubricating said shaft while said second vane assembly rotates relative thereto; a drive sprocket secured to said shaft within said housing; a projection on said output shaft extending inwardly from said sprocket and said end housing member; a cavity in the end of said shaft; a sleeve bearing in said cavity rotatably supporting said second vane assembly; a lubricating passage in said output shaft and said projection connecting with said passage in said vane shaft providing for transmission of lubricant under pressure from said oil pump; a pair of idler sprockets rotatably mounted on said end housing member within said housing and in spaced relation to said shaft sprocket; an endless chain disposed upon said sprocket and said idler sprockets for movement thereon; a pair of idler wheels rotatably mounted on said end housing member adjacent said drive sprocket in close proximity to said endless chain retaining the chain upon said drive sprocket; a first extended connecting pin in said chain engaging the slot in said first drive member and a second extended connecting pin in said chain engaging the slot in said second drive member whereby said first and second vane assemblies rotate and oscillate relative to one another at varying speeds causing adjacent vanes to approach and recede from each other thereby providing inlet, compression, expansion and exhaust cycles during each revolution of said vane assemblies.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,858,560 Dated January 7, 1975

Inventor(s) James A. Harrington

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 31, "To" should read -- Two --; line 37, "vanve" should read -- vane --; line 54, "pass" should read -- past --. Column 3, line 18, "process" should read -- power --; line 26, "rotatable" should read -- rotatably --; line 34, "dividing" should read -- driving --; line 65, "necting" should read -- nection --. Column 6, line 32, "worker" should read -- working --.

Signed and Sealed this

Third Day of August 1976

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks