United States Patent [19]

Morgan et al.

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[54] ROTARY ENGINE OIL METERING PUMP

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

[22] Filed: **May 3, 1973**

[21] Appl. No.: **357,072**

[52] **U.S. Cl.** .... **428/84,** 123/196 R, 417/461, 418/88

[51] **Int. Cl.** **F04c 29/02**

[58] **Field of Search** ...... 91/505; 417/461, 462, 228; 418/84, 88, 99; 123/196 R; 184/6.16, 26, 35; 92/12.2

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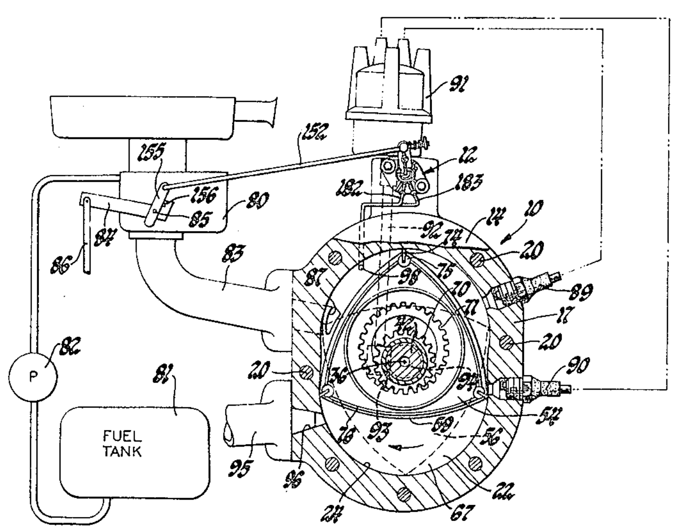
Assistant Examiner—Leonard Smith

Attorney, Agent, or Firm—Ronald L. Phillips

[57] **ABSTRACT**

A rotary engine is provided with an oil metering pump having a shaft that is rotatably mounted in the pump's body and is driven by the engine at a speed proportional thereto. A piston carried by the shaft is caused to reciprocate to expand and contract a pumping chamber in the shaft by contact with a pivoted plate whose angle determines the length of stroke and is controlled according to engine throttle opening. An inlet port in the pump body is supplied with oil from the engine's lubrication system and is connected by a timing port in the shaft with the pumping chamber as the chamber expands with this same timing port then during the same shaft revolution connecting the chamber to discharge oil to an outlet port in the pump body which is connected to deliver the oil to lubricate the engine's gas seals. In addition, a valve is located in the pump body that operates to provide pressure balance between the inlet and outlet ports. With this arrangement the pump meters oil to the outlet port with a high volumetric efficiency and minimum leakage between inlet and outlet and at a rate which increases with increasing throttle opening and engine speed and thus with increasing engine load.

10 Claims, 14 Drawing Figures



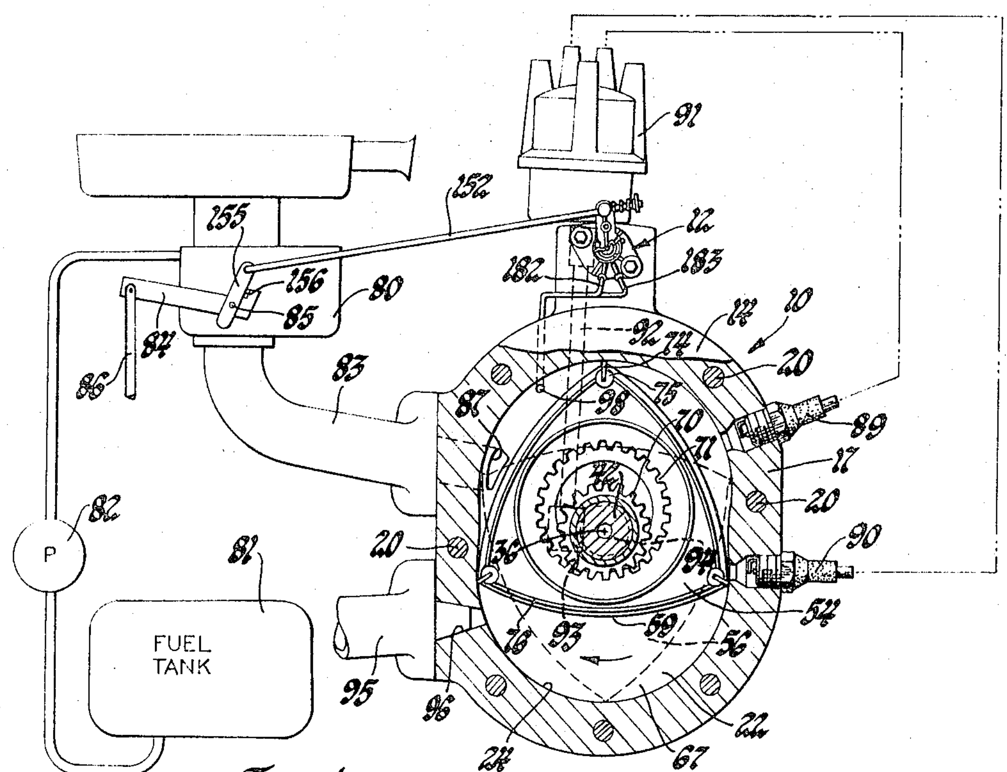


Fig. 1

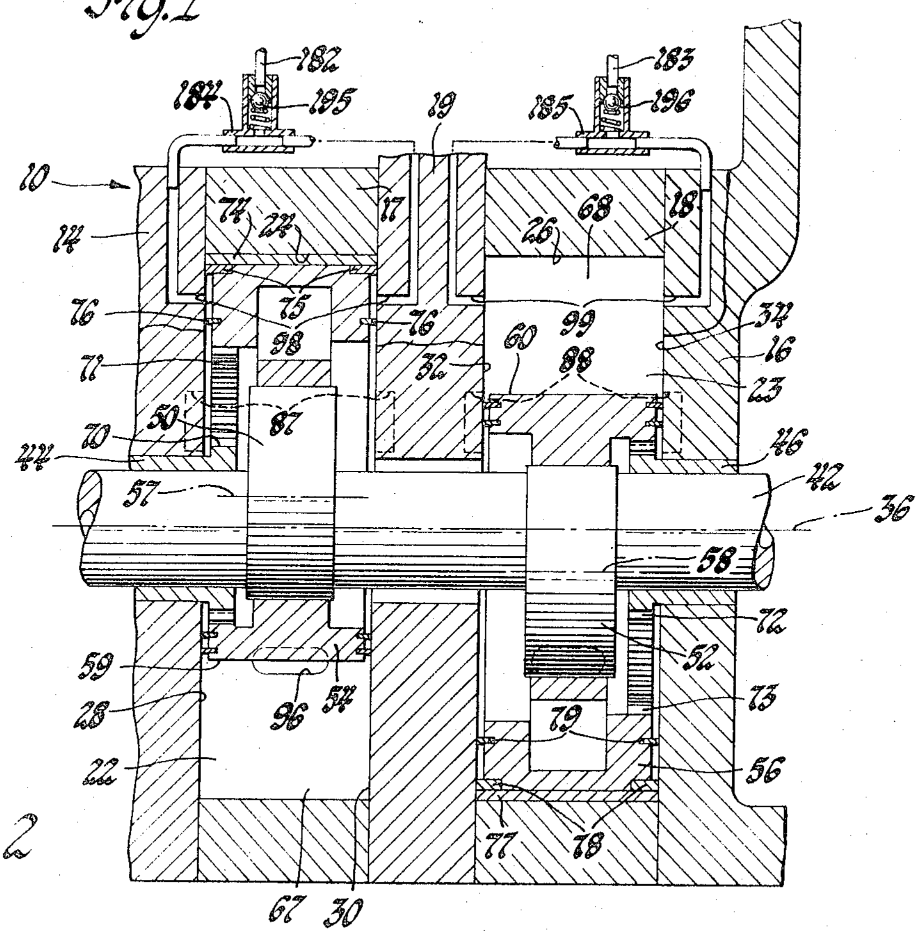


Fig. 2

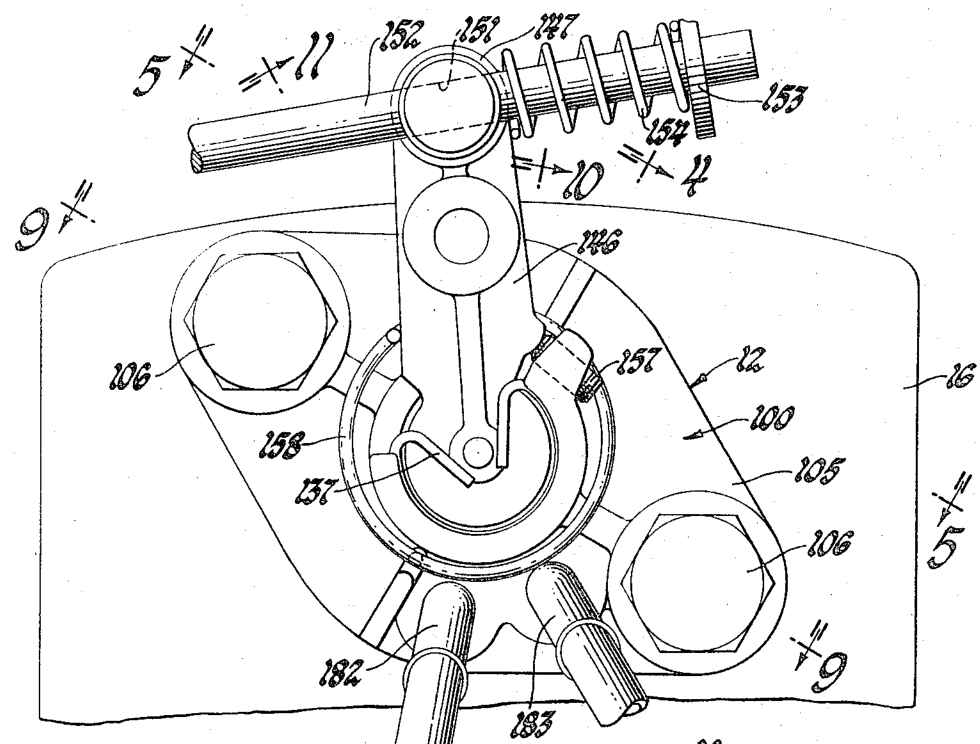

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Fig. 3

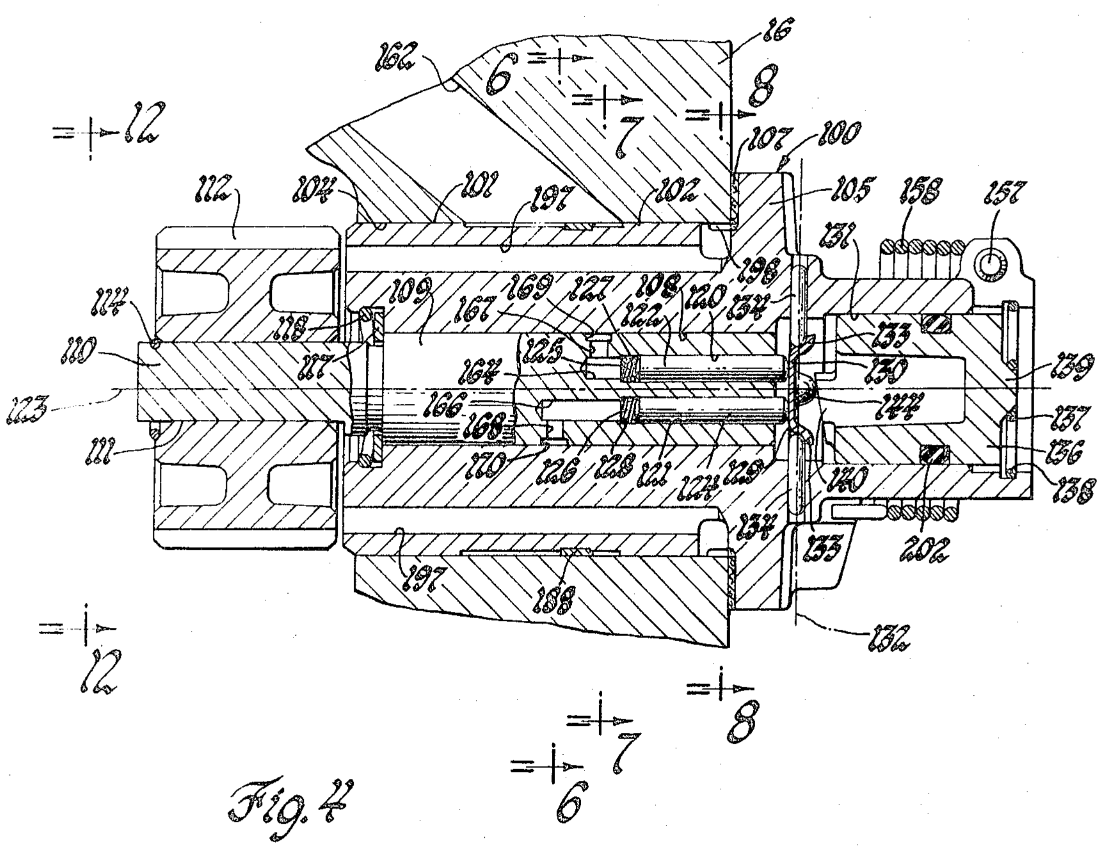
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Fig. 4

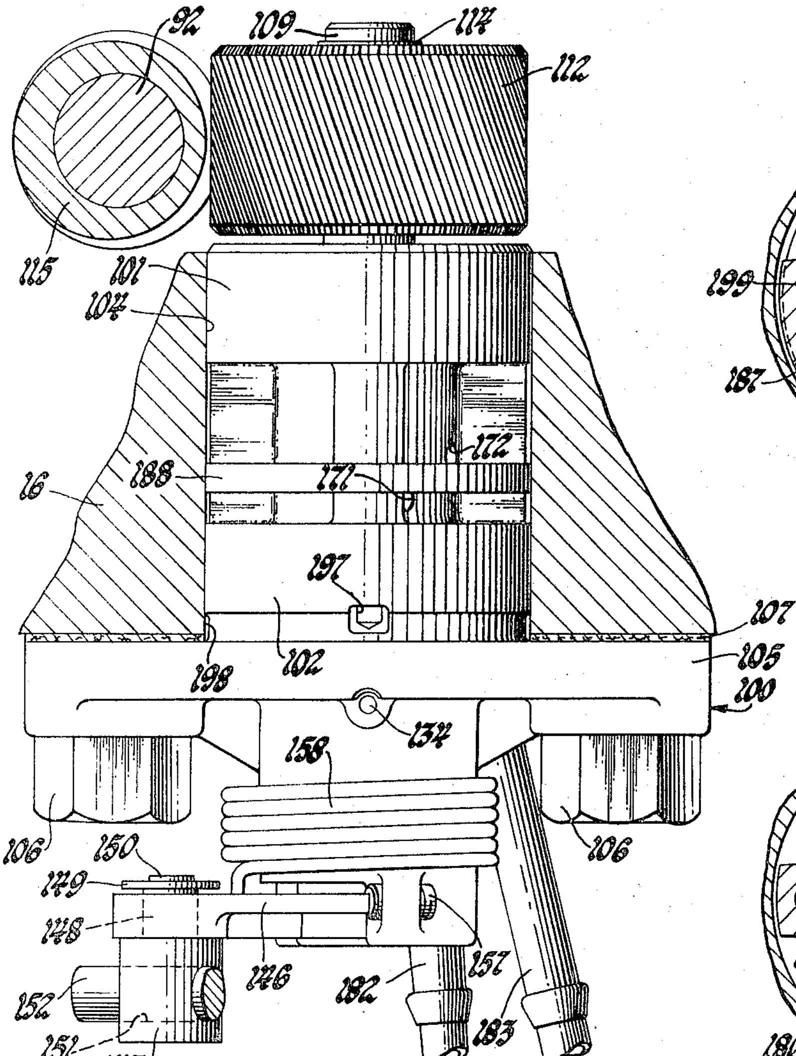

Fig. 5

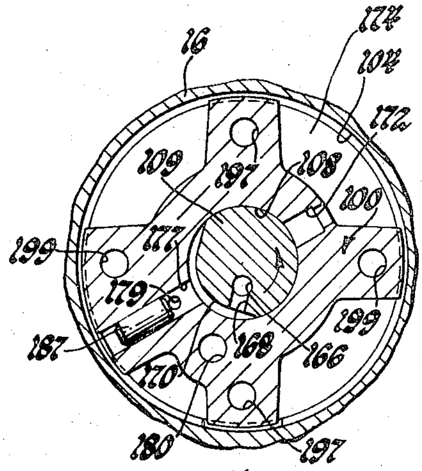

Fig. 6

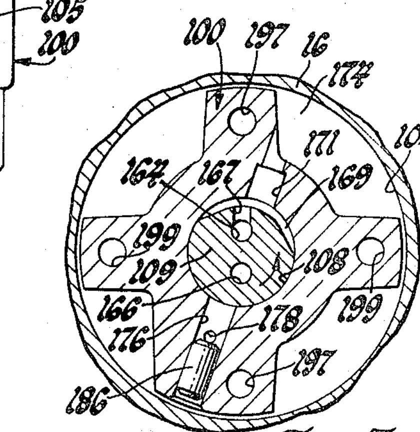

Fig. 7

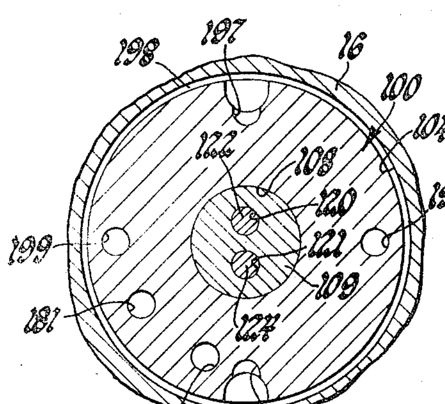

Fig. 8

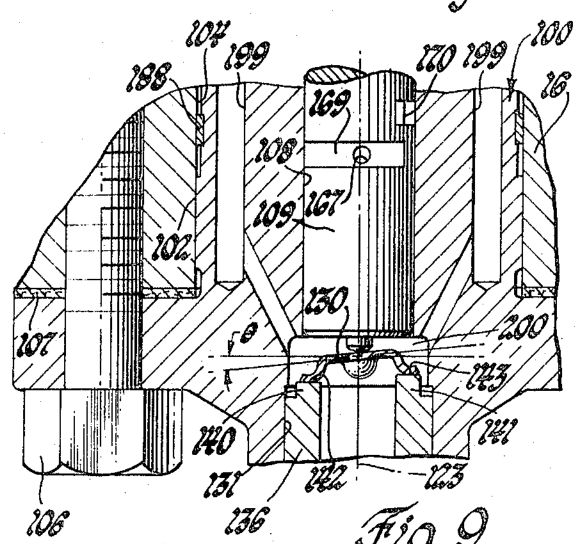

Fig. 9

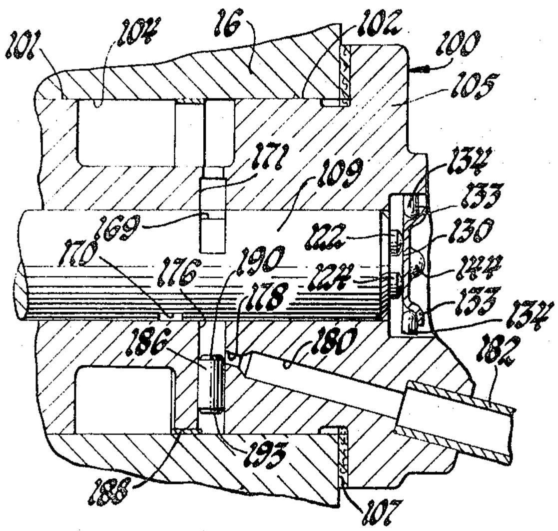

Fig. 10

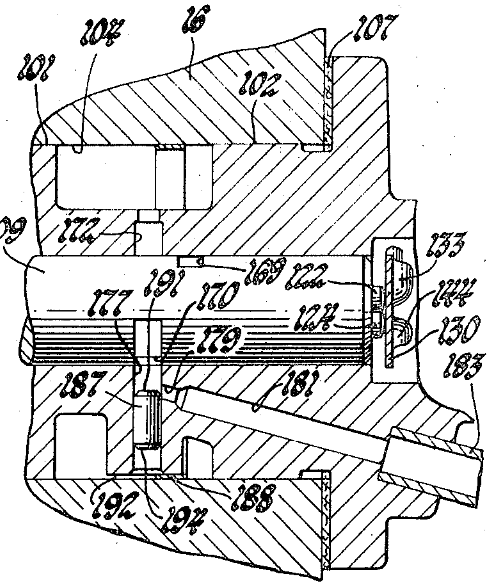

Fig. 11

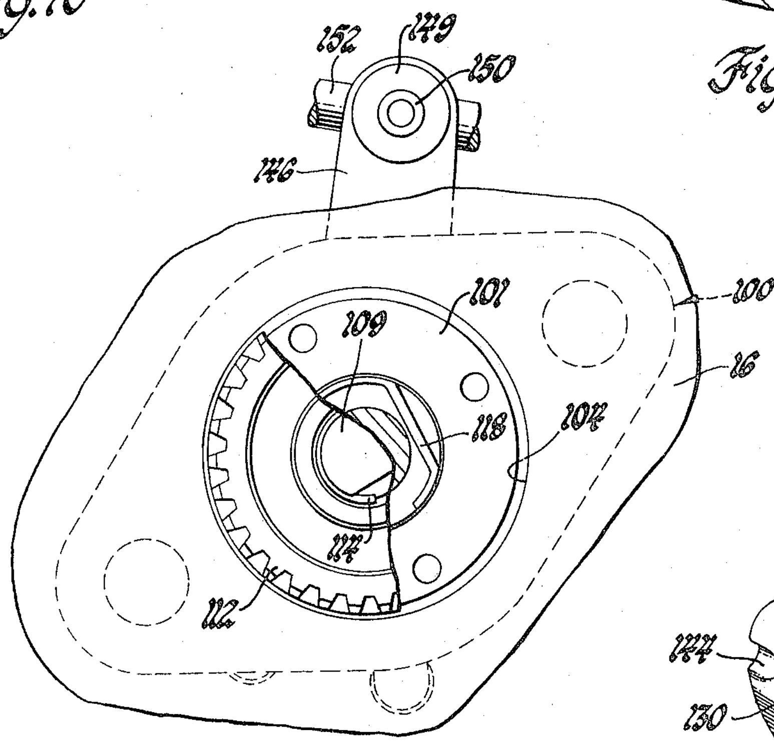

Fig. 12

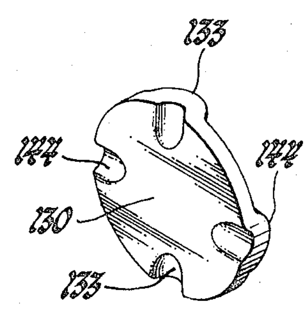

Fig. 13

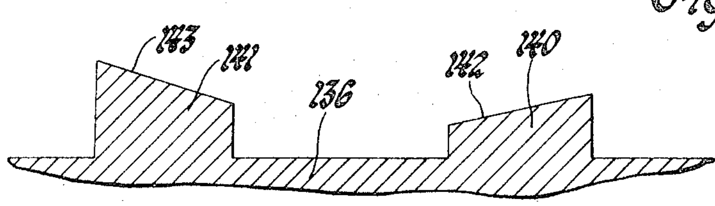

Fig. 14

ROTARY ENGINE OIL METERING PUMP

This invention relates to a rotary engine oil metering pump and more particularly to an oil metering pump that meters oil to lubricate a rotary engine's gas seals in accordance with engine speed and throttle opening.

In a rotary engine, it is desirable to meter oil to lubricate the engine rotor's gas seals at a rate that increases with increasing engine load. It is recognized that one way of doing this is to meter the oil at a rate that increases with increasing engine speed and torque demand as indicated by engine throttle opening. While there are presently commercial pumps that product such oil metering operation, there is a continuing effort for simplification and reduction in the size of the pump coupled with increased reliability and reduction in cost. Furthermore, it is particularly desirable that the pump have a high volumetric efficiency and little leakage between inlet and outlet so that the precise amount of oil determined to meet the gas seal lubrication requirement at a certain load is actually delivered to satisfy the demand.

The rotary engine oil metering pump according to the present invention is directed to the above goals and comprises a pump body in which is mounted a shaft that is drivingly connected to the engine's output shaft so that it turns at a speed proportional thereto when the engine is running. The pump shaft has an eccentrically located axially extending cylinder in which is mounted a piston that contacts a pivoted plate and on shaft rotation is caused by contact with the plate to reciprocate to expand and contract a pumping chamber at one end of the cylinder. A cam linked with the engine's throttle linkage controls the angle of the pivoted plate so that the piston stroke increases with increasing engine throttle opening as the pump shaft turns. A timing port in the shaft connects the chamber with an inlet port in the pump body that is connected to the engine's lube system with the connection between the inlet port and the chamber occurring as the chamber expands. Then as the pumping chamber contracts as the pump shaft completes a revolution, the timing port connects the chamber to deliver the oil thus received to an outlet port in the pump body which is connected by a delivery port to deliver oil to lubricate the engine's gas seals. A balance valve having opposed pressure responsive areas that are equal and that are separately acted on by pump inlet and pump outlet pressure operates to control the opening of the outlet port to the discharge port to effect a continuous pressure balance between the inlet and outlet. With this arrangement there is no pressure differential between pump inlet and outlet so that the filling and emptying of the chamber is unaffected by variations in supply pressure to the pump and also in the pressure downstream of the discharge port which has the effect of providing the pump with high volumetric efficiency while also ensuring minimum leakage between inlet and outlet. With this arrangement the pump thus operates to precisely meter oil for gas seal lubrication at a rate that increases with increasing engine speed and increasing engine throttle opening.

An object of the present invention is to provide a new and improved oil metering pump for a rotary engine.

Another object is to provide a new and improved oil metering pump for a rotary engine having minimum leakage between inlet and outlet and a high volumetric efficiency unaffected by variations in supply and delivery pressure.

Another object is to provide a rotary engine oil metering pump having a shaft that is driven by the engine and carries a pumping chamber which is expanded and contracted by a piston that is caused to reciprocate by a tiltable plate which is linked with the engine throttle linkage to vary piston stroke and with the shaft further having a timing port that connects an engine lube system supplied inlet port with the chamber during expansion and with an outlet port for delivery to the engine's gas seals during contraction all within each pump shaft revolution.

Another object is to provide a rotary engine oil metering pump having a shaft that is engine driven and has a chamber that is expanded and contracted by a shaft-carried piston that operates against a pivoted plate linked with the engine throttle linkage so that the piston stroke increases with increasing engine throttle opening with the shaft also having a timing port connecting an oil pressure supply inlet port to the pumping chamber as it expands and connecting the chamber to an outlet port to deliver the oil for gas seal lubrication as the chamber contracts and with a valve operated on by pump inlet and outlet pressures effecting high volumetric efficiency and minimal leakage between pump inlet and outlet.

Another object is to provide a new and improved rotary engine oil metering pump that has simple structure which is highly reliable and small in size and provides for a high volumetric efficiency and minimum leakage to effect precise oil metering at a rate that increases with increasing speed and engine throttle opening for delivery to lubricate the engine's gas seals.

These and other objects of the invention will become more apparent with reference to the following description and drawing in which:

FIG. 1 is an elevational view with parts shown diagrammatically and parts in section of a rotary engine having an oil metering pump according to the present invention.

FIG. 2 is an enlarged partial longitudinal view of the engine in FIG. 1.

FIG. 3 is an enlarged view of the oil metering pump in FIG. 1.

FIG. 4 is a view of the oil metering pump taken along the line 4—4 in FIG. 3.

FIG. 5 is a view of the oil metering pump taken along the line 5—5 in FIG. 3.

FIG. 6 is a view of the oil metering pump taken along the line 6—6 in FIG. 4.

FIG. 7 is a view of the oil metering pump taken along the line 7—7 in FIG. 4.

FIG. 8 is a view of the oil metering pump taken along the line 8—8 in FIG. 4.

FIG. 9 is a view of the oil metering pump taken along the line 9—9 in FIG. 3.

FIG. 10 is a view of the oil metering pump taken along the line 10—10 in FIG. 3.

FIG. 11 is a view of the oil metering pump taken along the line 11—11 in FIG. 3.

FIG. 12 is a view of the oil metering pump taken along the line 12—12 in FIG. 4.

FIG. 13 is a perspective view of the oil metering pump's pivoted plate.

FIG. 14 is an enlarged view of a plan development of the oil metering pump's cam.

Referring to FIGS. 1 and 2, there is shown a rotary engine 10 having an oil metering pump 12 according to the present invention that operates to meter oil to lubricate the engine's gas seals according to engine load. The engine 10 has an outer body comprising a pair of end housings 14 and 16, a pair of rotor housings 17 and 18, and an intermediate housing 19 between the two rotor housings 17 and 18, all clamped together by bolts 20. The engine housing encloses a pair of rotor cavities 22 and 23 that are defined respectively by inwardly facing peripheral walls 24 and 26 of rotor housings 17 and 18 and opposed, spaced parallel end walls 28, 30 and 32, 34 of the end housing 14 and intermediate housing 19 and the latter housing and other end housing 16. Each of the peripheral walls 24 and 26 is in the shape of a two-lobe epitrochoid or curve parallel thereto whose center line is indicated at 36. A crankshaft 42 which is the engine's output extends through the cavities 22 and 23 and is rotatably supported by sleeve bearings 44 and 46 which are fixed in the respective end housings 14 and 16, the crankshaft's axis being coincident with the center line 36 which is parallel to the peripheral walls 24 and 26.

The crankshaft 42 is provided in the cavities 22 and 23 with eccentrics 50 and 52 on which rotors 54 and 56 are mounted for rotation about the eccentric's axes 57 and 58, these axes being located 180° apart and spaced equal distances from the crankshaft axis 36. The rotors 54 and 56 have the same general shape of a triangle having respectively three faces 59 and 60 which are convex and face the peripheral walls 24 and 26 and cooperate therewith and with the end walls 28, 30 and 32, 34 to define three variable volume working chambers 67 and 68 that are spaced about the rotors and move with the rotors within the engine housing.

A fixed cyclic relation between each of the rotors and the crankshaft is obtained by gearing between each of the rotors and the housing. Referring to rotor 54, there is provided an annular gear 70 which is fixed to the housing by being formed integral with the stationary bearing 44 and is concentric with the crankshaft 42. The gear 70 meshes with an internally toothed gear 71 that is concentric with and formed on the outboard side of rotor 54. The gear 71 has one and one-half times the number of teeth as the gear 70 with result that this gearing enforces a fixed cyclic relation such that the crankshaft makes three complete revolutions for every one complete revolution of the rotor. Similar gears 72 and 73 that mesh at a location diametrically opposite that of gears 70 and 71 are provided for the other rotor 56. Thus, the chambers 67 and 68 revolve with the respective rotors 54 and 56 as they revolve about their axis while also revolving about the crankshaft axis with each chamber twice undergoing expansion and contraction during each rotor revolution and the chambers in the two rotor cavities phased 60° apart.

Sealing of the working chambers in each rotor cavity such as the working chambers 67 is effected by three apex seals 74 each of which extends the width of the rotor and is mounted in an axially extending groove at one of the rotor apexes, six corner seals 75 each of which is mounted in a bore on one of the rotor sides near one of the rotor apexes, and six side seals 76 each of which is mounted in an arcuate groove in one of the rotor sides and extends adjacent one of the rotor faces between two of the corner seals with the corner seals each providing a sealing link between one apex seal and the adjacent ends of two side seals. The apex seals 74 are urged radially outward by spring means, not shown, to continuously engage the peripheral wall 24 and both the corner seals 75 and the side seals 76 in both rotor sides are urged axially outward by suitable spring means, not shown, to continuously engage the respective end walls 28 and 30. The rotor 56 carries a similar gas sealing arrangement 77, 78 and 79.

Referring to FIG. 1, a carburetor 80 supplied with fuel from a fuel tank 81 by a fuel pump 82 delivers a combustible air-fuel mixture to an intake manifold 83 under the control of the carburetor's throttle valve. The throttle valve's opening is controlled by a throttle lever 84 that is connected to one end of the throttle valve's pivot shaft 85. The other end of lever 84 is pivotally connected to a rod 86 that is linked to an accelerator pedal, not shown, for control by the vehicle operator, the throttle valve arrangement being such that it is open when the throttle lever 84 is pivoted in a counterclockwise direction as viewed in FIG. 1. The intake manifold 83 is connected to the engine housing and has branches which communicate in the engine housing with pairs of intake ports 87 and 88 in the respective end walls 28, 30 and 32, 34. Upon rotor rotation in the direction indicated by the arrow in FIG. 1, combustible air-fuel mixture is sequentially, periodically admitted to the chambers 67 and 68 as they are expanding by the traversing motion of the motor sides relative to the respective intake ports 87 and 88 whereafter the chambers then close to their intake ports and contract to compress the thus trapped air-fuel mixture in readiness for ignition. Combustion by spark ignition is provided by a conventional ignition system, there being provided two spark plugs to ignite the mixture in each chamber, such as the spark plugs 89 and 90 shown in FIG. 1, which are for igniting the mixture in chambers 67. Sequential ignition of the air-fuel mixture in the chambers 67 is effected by the spark plugs 89 and 90 receiving timed ignition pulses from a distributor 91 which is mounted on the end housing 16 with the axis of its shaft 92 at right angles to the crankshaft axis 36. The distributor's shaft 92 is driven by the crankshaft 42 via a pinion 93 which is secured to the lower end of the shaft and meshes with a worm gear 94 that is formed on the crankshaft. The electrodes of the spark plugs are open to the chambers 67 through the rotor housing interior wall 24 and are peripherally spaced thereabout so that the plug 90 is said to lead the other plug 89. The spark plugs may be fired according to certain engine operating conditions as is well known. With combustion the peripheral wall takes the reaction to force the rotor to continue rotating and eventually each working chamber following the power phase is exhausted during the exhaust phase to an exhaust manifold 95 via an exhaust port 96 in the peripheral wall 24 that is periodically traversed by the rotor apexes. Similarly, the other chambers 68 are served by two similar spark plugs, not shown, that receive timed voltage pulses from the distributor 91 with the mixture being taken in through their intake ports 88 and being exhausted through an exhaust port.

The oil metering pump 12 according to the present invention is well suited to metering oil for delivery to the dual rotor engine of the above type via a gas seal lubrication system like that disclosed in copending U.S. Pat. application Ser. No. 271,758, entitled "Rotary Engine Gas Seal Lubrication System," filed July 14, 1972 by James M. Casey. In this type of gas seal lubrication system the metered oil is supplied to pairs of oil feed ports 98 and 99 in the respective end walls 28, 30 and 32, 34. The oil feed ports 98 and 99 are located opposite each other at the same radial and angular locations relative to the crankshaft axis and close to and pass the respective end wall intake ports 87 and 88 in the direction of rotor rotation so that they are traversed or wiped by the respective rotor side seals during rotor motion the same as the end wall intake ports 87 and 88. With this arrangement the end wall oil feed ports 98 and 99 feed the oil they receive on to the end walls as the side seals sequentially wipe past after having wiped past the end wall intake ports. Most of the oil thus delivered is wiped across the end walls and the remainder is thrown by centrifugal force to lubricate the peripheral walls. For further details of such a gas seal lubrication system reference should be made to the aforementioned patent application. We have found in a system of this type that it is desirable to provide separate metered oil supplies for the pair of oil feed ports 98 and 99 to assure that one pair of ports does not starve the other or there otherwise results some disproportionate supply thereto.

Describing now the oil metering pump 12 which is operable to provide separate oil metering to the pairs of oil feed ports 98 and 99, there is, as shown in FIGS. 3, 4 and 5, a pump body 100 which has a pair of spaced equal diameter cylindrical lands 101 and 102 which closely fit in a cylindrical bore 104 in an upper portion of the end housing 16. The pump body 100 has a flange portion 105 which is secured to the end housing 16 by a pair of bolts 106 with a gasket 107 being provided between the pump body and housing to prevent leakage. As best shown in FIG. 4, the pump body 100 has a central cylindrical bore 108 which extends axially completely therethrough and together with bore 104 is at right angles to the distributor shaft 92. A pump shaft 109 is rotatably mounted with a close fit in the bore 108 and extends outward of the pump body 100 at its left-hand end, as viewed in FIG. 4, into the end housing 16 in which the distributor shaft 92 is located. The left-hand end of pump shaft 109 has a reduced diameter portion 110 having a flat 111 which is received in a corresponding aperture in a pinion 112 whereby relative rotation between these parts is prevented. The pinion 112 is retained on shaft 109 by a split retaining ring 114 as shown in both FIGS. 4 and 12. The pinion 112 meshes with a worm gear 115 secured to the distributor shaft 92 to thus provide a drive connection between the distributor shaft 92 and the pump shaft 109 whereby the pump shaft is driven at a speed proportional to engine speed.

In this arrangement the helix of the gears 93, 94 and gears 112, 115 in the drive to the pump is in the same direction and the distributor shaft 92 is on corresponding sides of the crankshaft 42 and pump shaft 109 so that the distributor shaft 92 rotates counterclockwise as viewed in FIG. 4, resulting in leftward axial thrust on the pump shaft 109. This thrust is taken by a thrust washer 117 that adjacent its outer diameter engages a shoulder formed by a counter bore in the left-hand end of the body and adjacent its inner diameter engages a shoulder on the pump shaft 109 formed with the reduced diameter portion 110. The thrust washer 117 is backed up by a retaining spring 118 which is bottomed on its left-hand side against a rightwardly facing shoulder provided in the central opening in the pump body 100 as shown in FIG. 4. The pump shaft 109 has bored from its right-hand end a pair of cylinders 120 and 121 which extend parallel to the pump shaft axis 123 and are located diametrically opposite each other at the same radius and thereby have the same fixed eccentricity. Solid cylindrical pistons 122 and 124 are closely fitted in the respective bores or cylinders 120 and 121 for reciprocal movement. The pistons 122 and 124 cooperate with the cylinders 120 and 121 to define expansible chambers 125 and 126, respectively, that expand and contract when the pistons are caused to reciprocate. Springs 127 and 128 are located in the chambers 125 and 126 to act on the inner ends of the respective pistons 122 and 124 to urge them in an axial direction outward of the pump shaft which is rightward as viewed in FIG. 4. The outer ends of the pistons 122 and 124 are rounded and are urged by the springs 127 and 128 to contact a flat or planar surface 129 of a pivot plate 130. The plate 130 is located in an enlarged diameter portion 131 of the pump body 100 outward of the flange 105 and is pivotal about a fixed axis 132 intersecting the pump shaft axis by provision of a pair of diametrically opposite sockets 133 which are formed on the plate 130 and receive the radially inner ends of a pair of radially extending diametrically opposite pivot pins 134 which are press-fitted in radial holes in the pump body 100. The sockets 133 are open-faced on their inboard side so that with the pins 134 pressed in place the pivot plate 130 may be inserted through the large diameter bore 131 whereafter a cylindrical cam member 136 may be inserted in this bore. The cam member 136 is retained in pump body 100 by a C-shaped wire spring 137 which has a constant radius portion received in a radially inwardly facing annular groove 138 in the pump body. The two ends of spring 137 extend radially inwardly and engage a centrally located conically shaped portion 139 on the outboard end of the cam member 136 to bias the cam member toward the pump shaft 109 which direction is leftward as viewed in FIG. 4. The cam member 136 at its inboard end has two diametrically opposite axially projecting cams 140 and 141 of different height, the cam 141 being the longer of the two as clearly shown in FIG. 14. The two cams 140 and 141 have cam surfaces 142 and 143 of opposite helix that engage with the outer rounded surfaces of another pair of sockets 144 on the pivot plate 130 which are located diametrically opposite each other and at right angles to the other pair of sockets 133. With the long cam 141 engaging one of the sockets 144 and the short cam 140 engaging the other socket 144, the plate 130 is tilted at an angle θ from a plane perpendicular to the pump shaft axis 123 as shown in FIG. 9. Furthermore, the directions of the cam helices are determined so that on counterclockwise turning of the cam member 136, as viewed in FIGS. 1 and 3, the angle θ of pump plate 130 increases.

The cam member 136 is linked to the engine's throttle linkage so that it is turned to increase the angle of the pivot plate 130 as the engine throttle is opened. Referring to FIGS. 3 and 5, a lever 146 is secured to turn the cam member 136 by being formed integral therewith at the outboard end. The other end of lever 146 has a socket 147 pivotably secured thereto by a socket spindle 148, a retaining washer 149 and a rivet 150. The socket 147 has a radial through-hole 151 slidably receiving a rod 152 which at its right-hand end has a retaining ring 153 in an annular groove and receives a coil spring 154 between the socket 147 and the retaining ring 153. The rod 152 is pivotally connected at its other end as shown in FIG. 1 to a lever 155 which is pivotably supported on the carburetor's throttle valve shaft 85 and is engaged by tang 156 on the throttle lever 84 to pivot counterclockwise to pull the rod 152 and thus turn the pump's cam member 136 counterclockwise as the engine throttle is opened. As shown in FIGS. 3 and 5, an adjustable stop provided by a set screw 157 that is threaded to the pump body 100 engages a stop pad formed on the cam member lever 146 to determine the pump's minimum displacement condition which is described in detail later. The lever 146 and thus the cam member 136 is biased to this stop position by a torsion spring 158 which as shown in FIGS. 4 and 5 is arranged about the outboard portion of the pump body 100 and engages at its opposite ends the pump body 100 and the lever 146 so that its force urges clockwise movement of the lever as viewed in FIGS. 1 and 3. The coil spring 154 on the pump linkage rod 152 maintains the lever 155 at the carburetor against the throttle lever tank 156 and yields to permit the rod 152 to slide in the socket 147 when the rod is pulled leftward beyond the maximum travel of the pump lever 146. In the minimum pump displacement condition with the lever 146 against the set screw 157, the pivot plate 130 is positioned at its minimum angle whereby as the pump shaft 109 turns the orbiting pistons 122 and 124 in maintaining contact with the angled flat surface 129 of the pivot plate reciprocate axially with a minimum stroke to expand and contract the pump chambers 125 and 126. Then as the lever 146 is pivoted with opening of the engine throttle, the angle of the pivot plate 129 is increased by means of the cams 140 and 141 operating on the pivot plate sockets 144. As the stroke of the pistons 122 and 124 increases with increasing pivot plate angle, so does the displacement, with this increase continuing until a full throttle condition is reached.

Describing now how oil is supplied to the pump 12, metered and then delivered to the oil feed ports 98 and 99 to lubricate the engine's gas seals, oil is obtained from the engine's pressurized lubrication system which includes a drilled passage 162 in the end housing that intersects with the bore 104 receiving the pump body 100 as shown in FIG. 4. The pumping chambers 125 and 126 are connected respectively by reduced diameter axially extending bores 164 and 166 of different lengths and then by radially extending bores 167 and 168 at different axial locations to axially spaced timing ports 169 and 170 which are formed in the exterior of the pump shaft 109. The circumferential length of the timing ports 169 and 170 is such that the respective inlet port closes as the respective outlet port opens with zero nominal overlap as shown in FIGS. 6 and 7 and are registerable on pump shaft rotation with radially extending correspondingly axially spaced inlet ports 171 and 172 in the pump body 100 which are open at their outer radius ends to a cavity 174 in bore 104 between the pump body 100 and the end housing 16 that is in turn open to the oil supply passage 162. The timing ports 169 and 170 are also registerable on continued pump shaft rotation with radially extending outlet ports 176 and 177 that are diametrically opposite the respective inlet ports 171 and 172. The inlet ports 171 and 172 and outlet ports 176 and 177 are located on radially opposite sides of the pivot axis 132 of the pivot plate 130 and relative to the pivot direction of this plate on increasing throttle opening so that the pivot plate moves away from the inlet ports and toward the outlet ports so that the inlet ports 171 and 172 connect with pump chambers 125 and 126 during chamber expansion and the outlet ports 176 and 177 connect with these chambers during chamber contraction. To facilitate oil discharge passage routing in the pump body 100, there is provided angular spacing between the outlet ports 176 and 177 and thus also between inlet ports 171 and 172 resulting in the inlet port 172 and outlet port 177 leading the respective inlet port 171 and outlet port 176 relative to the rotational direction of the pump shaft 109. To effect this difference so that the discharge and intake phases for the two chambers are identical, the timing ports 169 and 170 are centered at different railing angle locations relative to their chambers 125 and 126 with this difference corresponding to that between the inlet ports and the outlet ports and with the timing port 169 having a smaller trailing angle than the timing port 170. With this arrangement and an oil supply to the two inlet ports 171 and 172 with the pump shaft 109 turning counterclockwise as viewed in FIGS. 6 and 7, the timing port 169 connects the inlet port 171 to the chamber 125 so that oil flows into this chamber and assists the spring 127 in maintaining the piston 122 against the pivot plate 130 to expand this chamber while the other timing port 170 is connecting the other chamber 126 to the other outlet port 177 as the piston 124 is caused by the pivot plate to move to contract the latter chamber and thus force the oil out into the latter outlet port. Then with continued shaft rotation, the timing port 169 closes off the inlet port 171 and begins opening to the outlet port 176 as the piston 122 is formed by the pivot plate 130 to move to contract chamber 125 and thus displace oil from this chamber into this outlet port while the other timing port 170 is closing off the other outlet port 177 and begins opening the other inlet port 172 as the piston 124 is expanding chamber 125 to now receive oil. Thus, oil is supplied to the respective chambers 125 and 126 from the inlet ports 171 and 172 as they expand and thereafter oil is forced from these chambers to the respective outlet ports 176 and 177 as they contract for each turn of the pump shaft 109 with the amount of oil delivered to the outlet ports for gas seal lubrication proportional to the volumetric displacement of the chambers 125 and 126 and the number of turns per unit of time of the pump shaft 109. In the installation of the pump 12 and with the lever 146 in its fully clockwise position as viewed in FIG. 3 which is the minimum displacement condition and with the pump running at a specified speed at engine idle, the set screw 157 is adjusted in or out and then locked to give a specified output of oil to meet the lubrication requirements under such conditions. Thereafter, oil is metered to the outlet ports 176 and 177 for gas seal lubrication at a rate which increases from this minimum value with both increasing engine speed and increasing pump displacement which increases with increasing engine throttle opening and therefore with increasing engine torque demand.

To improve the volumetric efficiency of the pump and also minimize leakage between the inlet and outlet ports to thereby provide precise metering of the oil, the outlet ports 176 and 177, as shown in FIGS. 6, 7, 10 and 11, are connected at right angles by smaller diameter drilled discharge passages 178 and 179 which have enlarged diameter downstream portions 180 and 181 that are open to pipes 182 and 183. The pipes 182 and 183 are press-fitted to the pump body 100 and are connected to deliver the metered oil to the oil feed ports 98 and 99 in the engine housing, the pipe 182 dividing into two branches at a tee 184 to feed the oil feed ports 98 and the other pipe 183 dividing into two branches at a tee 185 to feed the other pair of oil feed ports 99 as shown in FIG. 2. The tees 184 and 185 are located external of the engine as close as possible to the respective oil feed ports 98 and 99 for reasons which will become more clear later. The oil supply pressure to the inlet ports 171 and 172 to the pump varies and would normally affect the pump's volumetric efficiency. Such an adverse effect is prevented by balance valves 186 and 187 which are located in the bore of the outlet ports 176 and 177 and control the connection between these ports and the discharge passages 178 and 179, respectively. The balance valves 186 and 187 are simple solid cylindrical elements having opposite ends of equal area. A split retaining ring 188 received in an external annular groove in the pump body 100 located between the axial positions of the outlet ports 176 and 177 and has a width determined so that it extends partially over the radially outer ends of these ports to retain the balance valves 186 and 187 in the pump body when the pump is assembled with the pump shaft 109 in place and prior to attachment of the pump to the engine. The pressure in the outlet ports 176 and 177 thus acts on the inner end 190 and 191 of the valves 186 and 187 while pressure at the inlet ports 171 and 172 is transmitted by the relief 192 in the pump body 100 between lands 101 and 102 to act on their opposite radially outer ends 193 and 194. With supply pressure thus acting on the valves 186 and 187 to close the outlet ports 176 and 177 to the discharge ports 178 and 179 and outlet pressure acting in the opposite direction on these valves to open the outlet ports to the discharge ports, the balance valves 186 and 187 reciprocate and control these openings to discharge and thereby establish a pressure balance between inlet and outlet pressure at the outlet ports 176 and 177 so that the oil being displaced is pumped at a pressure always equalling inlet pressure. Thus, the pumping chambers 125 and 126 discharge the oil at the same pressure at which they receive it which has the effect of providing these chambers with a consistently high volumetric efficiency. Furthermore, since there is no pressure differential between the inlet and outlet ports this balance valve arrangement also has the effect of minimizing leakage between these points with the result that clearance fits of the parts without seals between these points is made possible.

It has also been found that even though precise metering is thus made available from the pump, the oil feed ports 98 and 99 may not actually receive such precise quantities of oil since these ports are subjected to changing vacuum in the engine's working chambers. For example, there is produced a short period of high vacuum during coasting downhill or during downshifting and when this vacuum is applied to the pump 12 through the oil feed pipes 182 and 183, small volumes of air because of aereated oil supply pass through the pump and expand. During such expansion, the oil in the lines 182 and 183 is forced into the engine contrary to the speed and throttle signals. With most of the oil drawn into the engine during such periods of changing vacuum, the precise metering from the pump is not available again until the pump refills the lines. Such adverse effects are prevented by the use of spring-biased pressure regulating valves 195 and 196 which are located in the inlets of the tees 184 and 185 as shown in FIG. 2. The pressure regulator valves 195 and 196 operate to maintain a positive pressure between the pump 12 and these valves which are close to the oil feed ports 98 and 99.

Venting for the pump's hydraulic operation is provided by a pair of longitudinally extending diametrically opposite passages 197 in the pump body 100 that are drilled, as shown in FIG. 4, to connect an annular space 198 in the pump body 100 contiguous with the inner radius edge of gasket 107 to the interior of the engine's end housing 16. In addition, there is provided another pair of longitudinally extending passages 199 that are drilled as shown in FIG. 9 to drain oil to the interior of the engine's end housing 16 from the space 200 between the pump shaft 109 and cam member 136 where the pivot plate 130 is located. An oil seal 202 in the form of an "O"-ring received in an annular groove in the cam member 136 engages the enlarged diameter bore portion 131 of the pump body to prevent leakage out of the pump from space 200.

Thus, the pump 12 described above and constructed according to the present invention provides a precise oil metering rate with high volumetric efficiency and minimum leakage and to two separate outlet ports. However, it will be understood by those skilled in this art that for engines where only one metered rate is required, the pump is easily adapted thereto by having only one piston and chamber or by simply connecting one of the oil outlet ports back to the inlet. On the other hand, where additional separate oil metered rates are desired, there may be provided additional pumping stations along the axis of the pump. It will also be appreciated that with the particular structure of the pivot plate 130 either pair of the sockets 132 and 144 may receive the pivot pins 134 while the other pair is engaged by the cam member which makes for easy and proper assembly. Furthermore, it will be understood that the oil may also be supplied to the pump by gravity feed instead of under pressure and that the piston springs 127 and 128 may be eliminated where the supply oil is under pressure or where the pump is arranged so that gravity operates to maintain the pistons in contact with the pivot plate during their expansion stroke.

The above described embodiments are illustrative of the invention which may be modified within the scope of the appended claims.

We claim:

1. A rotary engine comprising a housing, an output shaft rotatably mounted in said housing, a rotor rotatably mounted on said output shaft, gas seals mounted on said rotor and engaging said housing, and a throttle for controlling delivery of an air-fuel mixture to run said engine, an oil metering pump comprising a pump body having a bore; a pump shaft mounted in said bore for rotation about an axis; means drivingly connecting said output shaft to rotate said pump shaft; said pump shaft having an axially extending cylinder open through one end thereof and spaced from said axis; a piston mounted for reciprocal movement in said cylinder; said

piston and cylinder cooperatively defining a chamber whose volume varies when said piston is reciprocated in opposite expanding and contracting directions; an inlet port in said pump body opening through said bore for supplying oil to said chamber; an outlet port in said pump body opening through said bore at an axial location opposite said inlet port for receiving oil from said chamber; a discharge passage in said pump body connected to said outlet port; passage means for delivering oil from said discharge passage to lubricate said gas seals; a timing port in said pump shaft at the same axial location as said inlet and outlet ports for alternately connecting said inlet and outlet ports to said chamber during each revolution of said pump shaft; a plate mounted in said pump body opposite said piston for movement about an axis intersecting and at right angles to said axis of said pump shaft; biasing means for biasing said piston outward of said cylinder in said expanding direction against said plate; plate control means mounted in said pump body for tilting said plate about said plate axis from a position perpendicular to said pump shaft axis whereby on turning of said pump shaft said piston is caused to move in said contracting direction and have a stroke that increases with increasing tilting of said plate; means operatively connecting said throttle to said plate control means so that said plate control means is effective to increase piston stroke with increasing throttle opening; said inlet and outlet ports located on radially opposite sides of said plate axis and relative to the tilting direction of said plate with increasing throttle opening so that said inlet port connects with said chamber during chamber expansion and said outlet port connects with said chamber during chamber contraction; and balance valve means mounted for reciprocal movement in said outlet port and acted on in opposite directions by oil pressure in said outlet port and said inlet port, respectively, for providing controlled valve connection between said outlet port and said discharge passage to establish pressure balance between said inlet port and said outlet port so that the oil being displaced by said piston is pumped at a pressure equalling the pressure at said inlet port and oil is supplied to said passage means at a rate which increases with increasing output shaft speed and increasing throttle opening.

2. A rotary engine comprising a housing, an output shaft rotatably mounted in said housing, a rotor rotatably mounted on said output shaft, gas seals mounted on said rotor and engaging said housing, and a throttle for controlling delivery of an air-fuel mixture to run said engine, an oil metering pump comprising a pump body having a bore; a pump shaft mounted in said bore for rotation about an axis; means drivingly connecting said output shaft to rotate said pump shaft; said pump shaft having an axially extending cylinder open through one end thereof and spaced from said axis; a piston mounted for reciprocal movement in said cylinder; said piston and cylinder cooperatively defining a chamber whose volume varies when said piston is reciprocated in opposite expanding and contracting directions; an inlet port in said pump body opening through said bore for supplying oil to said chamber; an outlet port in said pump body opening through said bore at an axial location opposite said inlet port for receiving oil from said chamber; a discharge passage in said pump body connected to said outlet port; passage means for delivering oil from said discharge passage to lubricate said gas seals; a timing port in said pump shaft at the same axial location as said inlet and outlet ports for alternately connecting said inlet and outlet ports to said chamber during each revolution of said pump shaft; a plate mounted in said pump body opposite said piston for movement about an axis intersecting and at right angles to said axis of said pump shaft; biasing means for biasing said piston outward of said cylinder in said expanding direction against said plate; cam means mounted in said pump body opposite said plate for engaging said plate so that said plate is tilted about said plate axis from a position perpendicular to said pump shaft axis as said cam means is turned whereby on turning of said pump shaft said piston is caused to move in said contracting direction and have a stroke that increases with increasing tilting of said plate; means operatively connecting said throttle to turn said cam means to increase piston stroke with increasing throttle opening; said inlet and outlet ports located on radially opposite sides of said plate axis and relative to the tilting direction of said plate with increasing throttle opening so that said inlet port connects with said chamber during chamber expansion and said outlet port connects with said chamber during chamber contraction; and balance valve means mounted for reciprocal movement in said outlet port and acted on in opposite directions by oil pressure in said outlet port and said inlet port, respectively, for providing controlled valve connection between said outlet port and said discharge passage to establish pressure balance between said inlet port and said outlet port so that the oil being displaced by said piston is pumped at a pressure equalling the pressure at said inlet port and oil is supplied to said passage means at a rate which increases with increasing output shaft speed and increasing throttle opening.

3. A rotary engine comprising a housing, an output shaft rotatably mounted in said housing, a rotor rotatably mounted on said output shaft, gas seals mounted on said rotor and engaging said housing, and a throttle for controlling delivery of an air-fuel mixture to run said engine, an oil metering pump comprising a pump body having a bore; a pump shaft mounted in said bore for rotation about an axis; means drivingly connecting said output shaft to rotate said pump shaft; said pump shaft having an axially extending cylinder open through one end thereof and spaced from said axis; a piston mounted for reciprocal movement in said cylinder; said piston and cylinder cooperatively defining a chamber whose volume varies when said piston is reciprocated in opposite expanding and contracting directions; an inlet port in said pump body opening through said bore for supplying oil to said chamber; an outlet port in said pump body opening through said bore at an axial location opposite said inlet port for receiving oil from said chamber; a discharge passage in said pump body connected to said outlet port; passage means for delivering oil from said discharge passage to lubricate said gas seals; a timing port in said pump shaft at the same axial location as said inlet and outlet ports for alternately connecting said inlet and outlet ports to said chamber during each revolution of said pump shaft; a plate mounted in said pump body opposite said piston for movement about an axis intersecting and at right angles to said axis of said pump shaft; biasing means for biasing said piston outward of said cylinder in said expanding direction against said plate; a cam member mounted in said pump body opposite said plate for

turning movement about said axis of said pump shaft; and cam member having two diametrically opposite axially projecting cams of different height and opposite inclination for engaging said plate so that said plate is tilted about said plate axis from a position perpendicular to said pump shaft axis as said cam member is turned whereby on turning of said pump shaft said piston is caused to move in said contracting direction and have a stroke that increases with increasing tilting of said plate; means operatively connecting said throttle to turn said cam member to increase piston stroke with increasing throttle opening; said inlet and outlet ports located on radially opposite sides of said plate axis and relative to the tilting direction of said plate with increasing throttle opening so that said inlet port connects with said chamber during chamber expansion and said outlet port connects with said chamber during chamber contraction; and balance valve means mounted for reciprocal movement in said outlet port and acted on in opposite directions by oil pressure in said outlet port and said inlet port, respectively, for providing controlled valve connection between said outlet port and said discharge passage to establish pressure balance between said inlet port and said outlet port so that the oil being displaced by said piston is pumped at a pressure equalling the pressure at said inlet port and oil is supplied to said passage means at a rate which inreases with increasing output shaft speed an increasing throttle opening.

4. A rotary engine comprising a housing, an output shaft rotatably mounted in said housing, a rotor rotatably mounted on said output shaft, gas seals mounted on said rotor and engaging said housing, and a throttle for controlling delivery of an air-fuel mixture to run said engine, an oil metering pump comprising a pump body having a bore; a pump shaft mounted in said bore for rotation about an axis; means drivingly connecting said output shaft to rotate said pump shaft; said pump shaft having an axially extending cylinder open through one end thereof and spaced from said axis; a piston mounted for reciprocal movement in said cylinder; said piston and cylinder cooperatively defining a chamber whose volume varies when said piston is reciprocated in opposite expanding and contracting directions; an inlet port in said pump body opening through said bore for supplying oil to said chamber; an outlet port in said pump body opening through said bore at an axial location opposite said inlet port for receiving oil from said chamber; a discharge passage in said pump body connected to said outlet port; passage means for delivering oil from said discharge passage to lubricate said gas seals; a timing port in said pump shaft at the same axial location as said inlet and outlet ports for alternately connecting said inlet and outlet ports to said chamber during each revolution of said pump shaft; a plate mounted in said pump body opposite said piston for movement about an axis intersecting and at right angles to said axis of said pump shaft; biasing means for biasing said piston outward of said cylinder in said expanding direction against said plate; a cam member mounted in said pump body opposite said plate for turning movement about said axis of said pump shaft; said cam member having two diametrically opposite axially projecting cams of different height and opposite inclination for engaging said plate so that said plate is tilted about said plate axis from a position perpendicular to said pump shaft axis as said cam member is turned whereby on turning of said pump shaft said piston is caused to move in said contracting direction and have a stroke that increases with increasing tilting of said plate; means operatively connecting said throttle to turn said cam member to increase piston stroke with increasing throttle opening; said inlet and outlet ports located on radially opposite sides of said plate axis and relative to the tilting direction of said plate with increasing throttle opening so that said inlet port connects with said chamber during chamber expansion and said outlet port connects with said chamber during chamber contraction; and pressure regulator valve means in said passage means remote from said outlet port for maintaining positive oil pressure in said passage means between said regulator valve means and said outlet port whereby oil is supplied from said passage means for the gas seal lubrication at a rate which always increases with increasing output shaft speed and increasing throttle opening.

5. A rotary engine comprising a housing, an output shaft rotatably mounted in said housing, a rotor rotatably mounted on said output shaft, gas seals mounted on said rotor and engaging said housing, and a throttle for controlling delivery of an air-fuel mixture to run said engine, an oil metering pump comprising a pump body having a bore; a pump shaft mounted in said bore for rotation about an axis, means drivingly connecting said output shaft to rotate said pump shaft; said pump shaft having an axially extending cylinder open through one end thereof and spaced from said axis; a piston mounted for reciprocal movement in said cylinder; said piston and cylinder cooperatively defining a chamber whose volume varies when said piston is reciprocated in opposite expanding and contracting directions; an inlet port in said pump body opening through said bore for supplying oil to said chamber; an outlet port in said pump body opening through said bore at an axial location opposite sai inlet port for receiving oil from said chamber; a discharge passage in said pump body connected to said outlet port; passage means for delivering oil from said discharge passage to lubricate said gas seals; a timing port in said pump shaft at the same axial location as said inlet and outlet ports for alternately connecting said inlet and outlet ports to said chamber during each revolution of said pump shaft; a plate mounted in said pump body opposite said piston for movement about an axis intersecting and at right angles to said axis of said pump shaft; a spring mounted in said chamber for biasing said piston outward of said cylinder in said expanding direction against said plate; a cam member mounted in said pump body opposite said plate for turning movement about said axis of said pump shaft; said cam member having two diametrically opposite axially projecting cams of different height and opposite inclination for engaging said plate so that said plate is tilted about said plate axis from a position perpendicular to said pump shaft axis as said cam member is turned whereby on turning of said pump shaft said piston is caused to move in said contracting direction and have a stroke that increases with increasing tilting of said plate; means operatively connecting said throttle to turn said cam member to increase piston stroke with increasing throttle opening; said inlet and outlet ports located on radially opposite sides of said plate axis and relative to the tilting direction of said plate with increasing throttle opening so that said inlet port connects with said chamber during chamber expansion

and said outlet port connects with said chamber during chamber contraction; balance valve means mounted for reciprocal movement in said outlet port and acted on in opposite directions by oil pressure in said outlet port and said inlet port, respectively, for providing controlled valve connection between said outlet port and said discharge passage to establish pressure balance between said inlet port and said outlet port so that the oil being displaced by said piston is pumped at a pressure equalling the pressure at said inlet port; and pressure regulator valve means in said passage means remote from said outlet port for maintaining positive oil pressure in said passage means between said regulator valve means and said outlet port whereby oil is supplied from said passage means for the gas seal lubrication at a rate which always increases with increasing output shaft speed and increasing throttle opening.

6. A rotary engine comprising a housing, an output shaft rotatably mounted in said housing, a pair of rotors rotatably mounted on said output shaft, gas seals mounted on each said rotor and engaging said housing and a throttle for controlling delivery of an air-fuel mixture to run said engine, an oil metering pump comprising a pump body having a bore; a pump shaft mounted in said bore for rotation about an axis; means drivingly connecting said output shaft to rotate said pump shaft; said pump shaft having first and second axially extending diametrically oppositely located cylinders open through one end thereof; first and second pistons mounted for reciprocal movement in said first and second cylinders, respectively; said first and second pistons and cylinders cooperatively defining first and second chambers, respectively, whose volumes vary when said pistons are reciprocated in opposite expanding and contracting directions; first and second inlet ports in said pump body opening through said bore at different axial locations for supplying oil to said first and second chambers, respectively; first and second outlet ports in said pump body opening through said bore at axial locations opposite said first and second inlet ports, respectively, for receiving oil from said first and second chambers; first and second discharge passages in said pump body connected to said first and second outlet ports, respectively; first and second passage means for delivering oil from said first and second discharge passages, respectively, to separately lubricate said gas seals on said rotors; first and second timing ports in said pump shaft at the same axial locations as said first and second inlet ports and outlet ports for alternately connecting said first and second inlet ports and said first and second outlet ports to said first and second chambers, respectively, during each revolution of said pump shaft; a plate mounted in said pump body opposite said pistons for movement about an axis intersecting and at right angles to said axis of said pump shaft; first and second biasing means for biasing said first and second pistons, respectively, outward of said cylinders in said expanding direction against said plate; plate control means mounted in said pump body for tilting said plate about said plate axis from a position perpendicular to said pump shaft axis whereby on turing of said pump shaft said pistons are caused to move in said contracting direction and have a stroke that increases with increasing tilting of said plate; means operatively connecting said throttle to said plate control means so that said plate control means is effective to increase piston stroke with increasing throttle opening, said inlet ports and outlet ports located on radially opposite sides of said plate axis and relative to the pivot direction of said plate with increasing throttle opening so that said first and second inlet ports connect with said first and second chambers, respectively, during chamber expansion and said first and second outlet ports connect with said first and second chambers, respectively, during chamber contraction; and first and second balance valve means mounted for reciprocal movement in said first and second outlet ports, respectively, and acted on in opposite directions by oil pressure in said first and second outlet ports and said first and second inlet ports, respectively, for providing controlled valve connections between said first and second outlet ports and said first and second discharge passages to establish pressure balance between said first and second inlet ports and said first and second outlet ports, respectively, so that the oil being displaced by said pistons is pumped at a pressure equalling the pressure at said inlet ports and oil is supplied to said first and second passage means at a rate which increases with increasing output shaft speed and increasing throttle opening.

7. A rotary engine comprising a housing, an output shaft rotatably mounted in said housing, a pair of rotors rotatably mounted on said output shaft, gas seals mounted on each said rotor and engaging said housing, and a throttle for controlling delivery of an air-fuel mixture to run said engine, an oil metering pump comprising a pump body having a bore; a pump shaft mounted in said bore for rotation about an axis; means drivingly connecting said output shaft to rotate said pump shaft; said pump shaft having first and second axially extending diametrically oppositely located cylinders open through one end thereof; first and second pistons mounted for reciprocal movement in said first and second cylinders, respectively; said first and second pistons and cylinders cooperatively defining first and second chambers, respectively, whose volumes vary when said pistons are reciprocated in opposite expanding and contracting directions; first and second inlet ports in said pump body opening through said bore at different axial locations for supplying oil to said first and second chambers; respectively, first and second outlet ports in said pump body opening through said bore at axial locations opposite said first and second inlet ports, respectively, for receiving oil from said first and second chambers; first and second discharge passages in said pump body connected to said first and second outlet ports, respectively; first and second passage means for delivering oil from said first and second discharge passages, respectively, to separately lubricate said gas seals on said rotors; first and second timing ports in said pump shaft at the same axial locations as said first and second inlet ports and outlet ports for alternately connecting said first and second inlet ports and said first and second outlet ports to said first and second chambers, respectively, during each revolution of said pump shaft; a plate mounted in said pump body opposite said pistons for movement about an axis intersecting and at right angles to said axis of said pump shaft; first and second biasing means for biasing said first and second pistons, respectively, outward of said cylinders in said expanding direction against said plate; cam means mounted in said pump body opposite said plate for engaging said plate so that said plate is tilted about said plate axis from a position perpendicular to said pump shaft axis as said cam means is turned whereby on turn-

ing of said pump shaft said pistons are caused to move in said contracting direction and have a stroke that increases with increasing tilting of said plate; means operatively connecting said throttle to turn said cam means to increase piston stroke with increasing throttle opening; said inlet ports and outlet ports located on radially opposite sides of said plate axis and relative to the pivot direction of said plate with increasing throttle opening so that said first and second inlet ports connect with said first and second chambers, respectively, during chamber expansion and said first and second outlet ports connect with said first and second chambers, respectively, during chamber contraction; and first and second balance valve means mounted for reciprocal movement in said first and second outlet ports, respectively, and acted on in opposite directions by oil pressure in said first and second outlet ports and said first and second inlet ports, respectively, for providing controlled valve connections between said first and second outlet ports and said first and second discharge passages to establish pressure balance between said first and second inlet ports and said first and second outlet ports, respectively, so that the oil being displaced by said pistons is pumped at a pressure equalling the pressure at said inlet ports and oil is supplied to said first and second passage means at a rate which increases with increasing output shaft speed and increasing throttle opening.

8. A rotary engine comprising a housing, an output shaft rotatably mounted in said housing, a pair of rotors rotatably mounted on said output shaft, gas seals mounted on each said rotor and engaging said housing, and a throttle for controlling delivery of an air-fuel mixture to run said engine, an oil metering pump comprising a pump body having a bore; a pump shaft mounted in said bore for rotation about an axis; means drivingly connecting said output shaft to rotate said pump shaft; said pump shaft having first and second axially extending diametrically oppositely located cylinders open through one end thereof; first and second pistons mounted for reciprocal movement in said first and second cylinders, respectively; said first and second pistons and cylinders cooperatively defining first and second chambers, respectively, whose volumes vary when said pistons are reciprocated in opposite expanding and contracting directions; first and second inlet ports in said pump body opening through said bore at different axial locations for supplying oil to said first and second chambers, respectively; first and second outlet ports in said pump body opening through said bore at axial locations opposite said first and second inlet ports, respectively, for receiving oil from said first and second chambers; first and second discharge passages in said pump body connected to said first and second outlet ports, respectively; first and second passage means for delivering oil from said first and second discharge passages, respectively, to separately lubricate said gas seals on said rotors; first and second timing ports in said pump shaft at the same axial locations as said first and second inlet ports and outlet ports for alternately connecting said first and second inlet ports and said first and second outlet ports to said first and second chambers, respectively, during each revolution of said pump shaft; a plate mounted in said pump body opposite said pistons for movement about an axis intersecting and at right angles to said axis of said pump shaft; first and second biasing means for biasing said first and second pistons, respectively, outward of said cylinders in said expanding direction against said plate; a cam member mounted in said pump body opposite said plate for turning movement about said axis of said pump shaft; said cam member having two diametrically opposite axially projecting cams of different height and opposite inclination for engaging said plate so that said plate is tilted about said plate axis from a position perpendicular to said pump shaft axis as said cam member is turned whereby on turning of said pump shaft said pistons are caused to move in said contracting direction and have a stroke that increases with increasing tilting of said plate; means operatively connecting said throttle to turn said cam member to increase piston stroke with increasing throttle opening; said inlet ports and outlet ports located on radially opposite sides of said plate axis and relative to the pivot direction of said plate with increasing throttle opening so that said first and second inlet ports connect with said first and second chambers, respectively, during chamber expansion and said first and second outlet ports connect with said first and second chambers, respectively, during chamber contraction; and first and second balance valve means mounted for reciprocal movement in said first and second outlet ports, respectively, and acted on in opposite directions by oil pressure in said first and second outlet ports and said first and second inlet ports, respectively, for providing controlled valve connections between said first and second outlet ports and said first and second discharge passages to establish pressure balance between said first and second inlet ports and said first and second outlet ports, respectively, so that the oil being displaced by said pistons is pumped at a pressure equalling the pressure at said inlet ports and oil is supplied to said first and second passage means at a rate which increases with increasing output shaft speed and increasing throttle opening.

9. A rotary engine comprising a housing, an output shaft rotatably mounted in said housing, a pair of rotors rotatably mounted on said output shaft, gas seals mounted on each said rotor and engaging said housing, and a throttle for controlling delivery of an air-fuel mixture to run said engine, an oil metering pump comprising a pump body having a bore; a pump shaft mounted in said bore for rotation about an axis; means drivingly connecting said output shaft to rotate said pump shaft; said pump shaft having first and second axially extending diametrically oppositely located cylinders open through one end thereof; first and second pistons mounted for reciprocal movement in said first and second cylinders, respectively; said first and second pistons and cylinders cooperatively defining first and second chambers, respectively, whose volumes vary when said pistons are reciprocated in opposite expanding and contracting directions; first and second inlet ports in said pump body opening through said bore at different axial locations for supplying oil to said first and second chambers, respectively; first and second outlet ports in said pump body opening through said bore at axial locations opposite said first and second inlet ports, respectively, for receiving oil from said first and second chambers; first and second discharge passages in said pump body connected to said first and second outlet ports, respectively; first and second passage means for delivering oil from said first and second discharge passages, respectively, to separately lubricate said gas seals on said rotor; first and second timing ports in said pump shaft at the same axial locations as said first and second inlet ports and outlet ports for alternately connecting said first and second inlet ports and said first and second outlet ports to said first and second chambers, respectively, during each revolution of said pump shaft; a plate mounted in said pump body opposite said pistons for movement about an axis intersecting and at right angles to said axis of said pump shaft; first and second biasing means for biasing said first and second pistons, respectively, outward of said cylinders in said expanding direction against said plate; a cam member mounted in said pump body opposite said plate for turning movement about said axis of said pump shaft; said cam member having two diametrically opposite axially projecting cams of different height and opposite inclination for engaging said plate so that said plate is tilted about said plate axis from a position perpendicular to said pump shaft axis as said cam member is turned whereby on turning of said pump shaft said pistons are caused to move in said contracting direction and have a stroke that increases with increasing tilting of said plate; means operatively connecting said throttle to turn said cam member to increase piston stroke with increasing throttle opening; said inlet ports and outlet ports located on radially opposite sides of said plate axis and relative to the tilting direction of said plate with increasing throttle opening so that said first and second inlet ports connect with said first and second chambers, respectively, during chamber expansion and said first and second outlet ports connect with said first and second chambers, respectively, during chamber contraction; and first and second pressure regulator valve means in said first and second passage means, respectively, remote from said first and second outlet ports, respectively, for maintaining positive oil pressure in said passage means between said first and second regulator valve means and said first and second outlet ports, respectively, whereby oil is supplied from said first and second passage means for the gas seal lubrication at a rate which always increases with increasing output shaft speed and increasing throttle opening.

10. A rotary engine comprising a housing, an output shaft rotatably mounted in said housing, a pair of rotors rotatably mounted on said output shaft, gas seals mounted on each said rotor and engaging said housing, and a throttle for controlling delivery of an air-fuel mixture to run said engine, an oil metering pump comprising a pump body having a bore; a pump shaft mounted in said bore for rotation about an axis; means drivingly connecting said output shaft to rotate said pump shaft; said pump shaft having first and second axially extending diametrically oppositely located cylinders open through one end thereof; first and second pistons mounted for reciprocal movement in said first and second cylinders, respectively; said first and second pistons and cylinders cooperatively defining first and second chambers, respectively, whose volumes vary when said pistons are reciprocated in opposite expanding and contracting directions; first and second inlet ports in said pump body opening through said bore at different axial locations for supplying oil to said first and second chambers, respectively; first and second outlet ports in said pump body opening through said bore at axial locations opposite said first and second inlet ports, respectively, for receiving oil from said first and second chambers; first and second discharge passages in said pump body connected to said first and second outlet ports, respectively; first and second passage means for delivering oil from said first and second discharge passages, respectively, to separately lubricate said gas seals on said rotors; first and second timing ports in said pump shaft at the same axial locations as said first and second inlet ports and outlet ports for alternately connecting said first and second inlet ports and said first and second outlet ports to said first and second chambers, respectively, during each revolution of said pump shaft; a plate mounted in said pump body opposite said pistons for movement about an axis intersecting and at right angles to said axis of said pump shaft; first and second springs mounted in said first and second chambers for biasing said first and second pistons, respectively, outward of said cylinders in said expanding direction against said plate; a cam member mounted in said pump body opposite said plate for turning movement about said axis of said pump shaft; said cam member having two diametrically opposite axially projecting cams of different height and opposite inclination for engaging said plate so that said plate is tilted about said plate axis from a position perpendicular to said pump shaft axis as said cam member is turned whereby on turning of said pump shaft said pistons are caused to move in said contracting direction and have a stroke that increases with increasing tilting of said plate; means operatively connecting said throttle to turn said cam member to increase piston stroke with increasing throttle opening; said inlet ports and outlet ports located on radially opposite sides of said plate axis and relative to the tilting direction of said plate with increasing throttle opening so that said first and second inlet ports connect with said first and second chambers, respectively, during chamber expansion and said first and second outlet ports connect with said first and second chambers, respectively, during chamber contraction; first and second balance valve means mounted for reciprocal movement in said first and second outlet ports, respectively, and acted on in opposite directions by oil pressure in said first and second outlet ports and said first and second inlet ports, respectively, for providing controlled valve connections between said first and second outlet ports and said first and second discharge passages to establish pressure balance between said first and second inlet ports and said first and second outlet ports, respectively, so that the oil being displaced by said pistons is pumped at a pressure equalling the pressure at said inlet ports; and first and second pressure regulator valve means in said first and second passage means, respectively, remote from said first and second outlet ports, respectively, for maintaining positive oil pressure in said passage means between said first and second regulator valve means and said first and second outlet ports, respectively, whereby oil is supplied from said first and second passage means for the gas seal lubrication at a rate which always increases with increasing output shaft speed and increasing throttle opening.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 3,841,803

DATED : October 15, 1974

INVENTOR(S) : Robert E. Morgan, James D. Palma

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 14, "product" should read -- produce --.
Column 4, line 66, "Serial No. 271,758" should read -- Serial No. 271,785 --.
Column 7, line 23, "tank" should read -- tang --.
Column 8, line 18, "railing" should read -- trailing --; line 36, "formed" should read -- forced --.
Column 9, line 32, "end" should read -- ends --.
Column 13, line 2, "and" should read -- said --; line 29, "an" should read -- and --.
Column 14, line 38, "sai" should read -- said -- (first occurrence).

Signed and sealed this 17th day of June 1975.

(SEAL)
Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents
and Trademarks