

[54] **ROTARY ENGINE OIL METERING PUMP**

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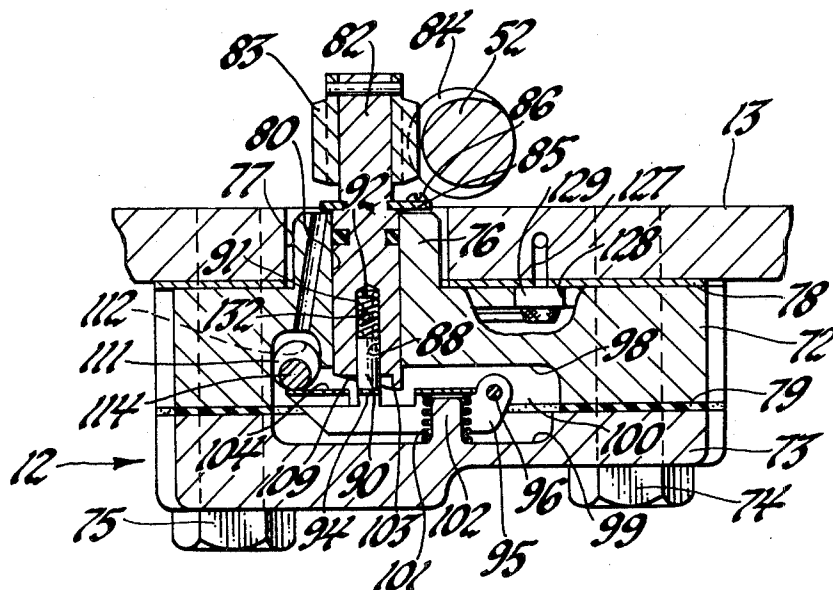
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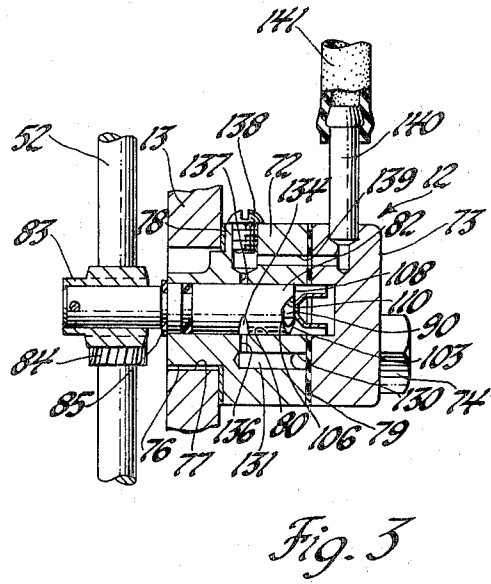
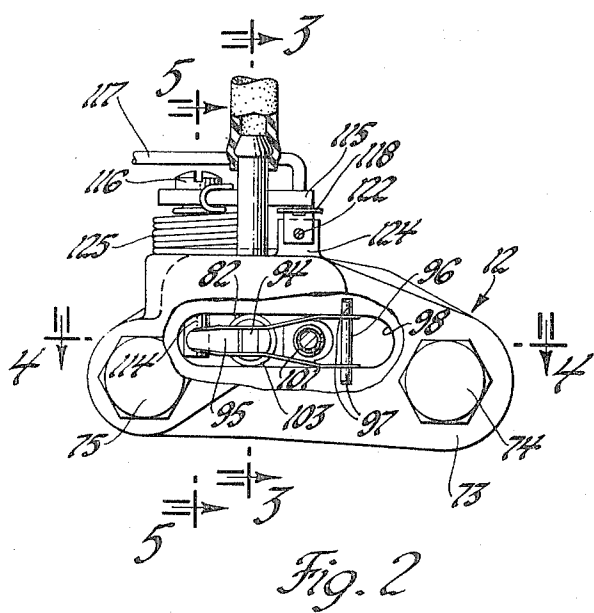
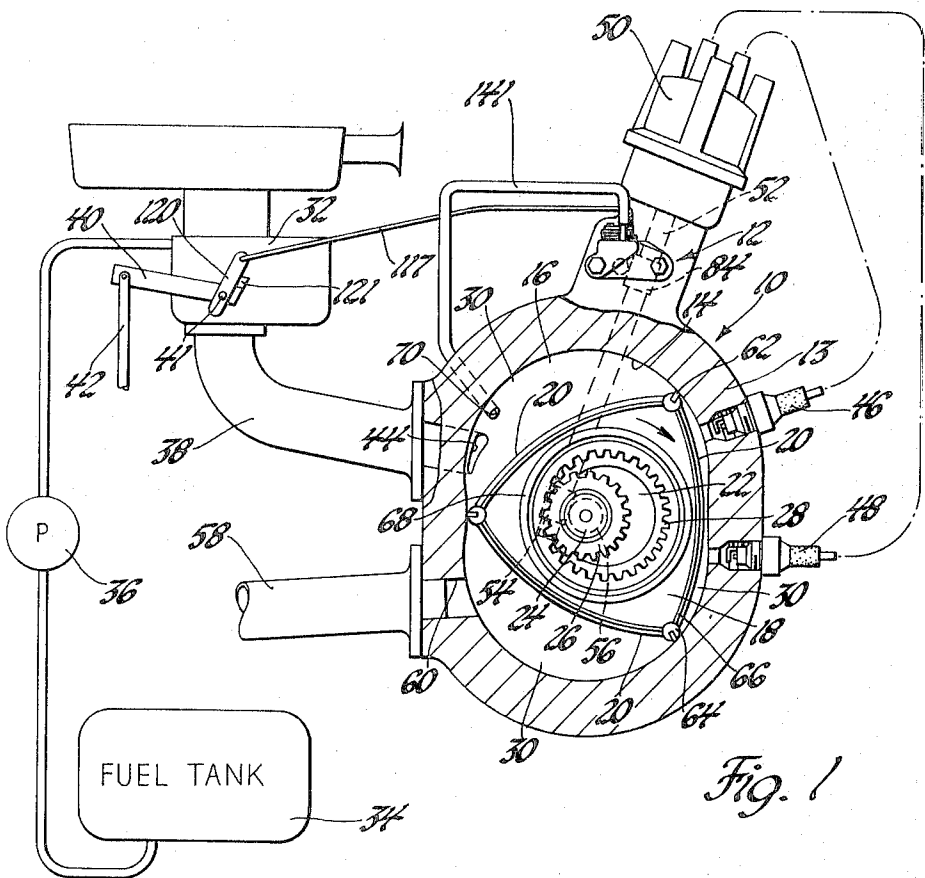
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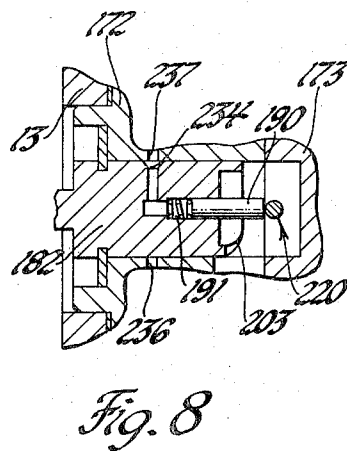
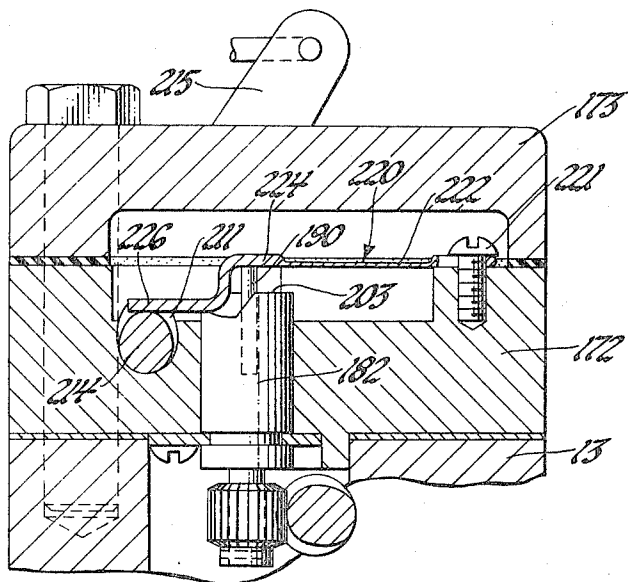
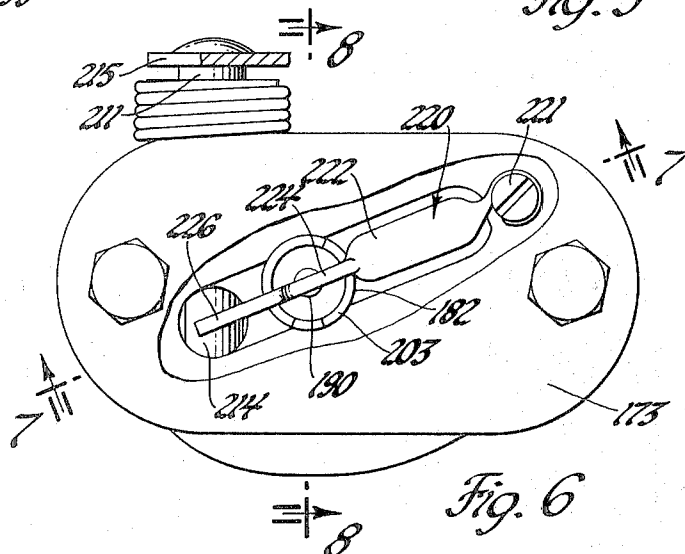
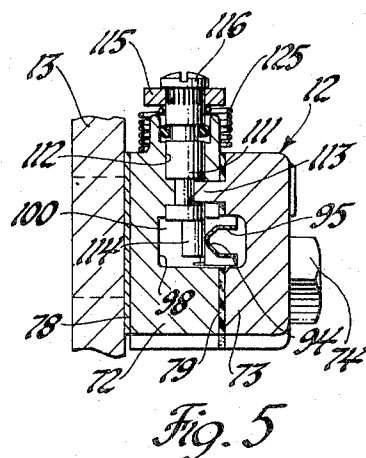
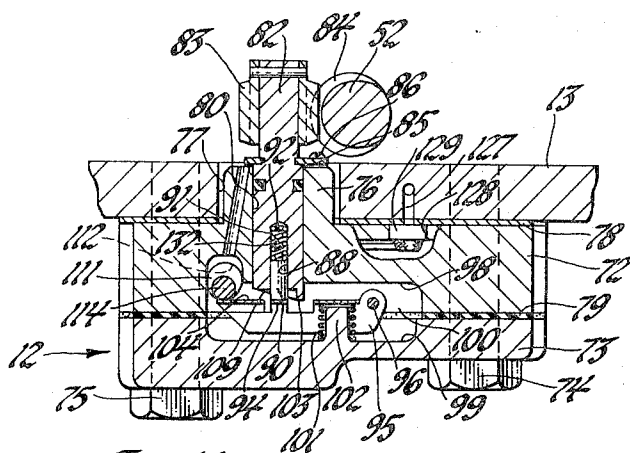
[57] **ABSTRACT**

An internal combustion rotary engine is provided with an oil metering pump having an engine driven pump shaft with a chamber and an axial plunger that is biased under the control of a cam on the pump shaft and also an engine throttle controlled cam to have a stroke that increases with increasing engine throttle opening to effect oil metering at a rate that increases with increasing engine speed and increasing throttle opening.

2 Claims, 8 Drawing Figures







ROTARY ENGINE OIL METERING PUMP

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

In meeting the lubrication needs of a rotary engine's gas seals, current practice is to meter oil for such lubrication at a rate that increases with engine load. It is known that this may be accomplished by metering 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 produce such oil metering operation, there is a continuing effort for simplification and reduction in size of the pump coupled with enhanced reliability and reduction in cost.

The rotary engine oil metering pump according to the present invention is directed to such goals and comprises a pump body that is securable to the engine's housing and has a bore in which a pump shaft is rotatably mounted. The pump shaft is driven by the engine and has therein a chamber which is expanded and contracted by reciprocation of an axial plunger. Oil from the engine's oil lubrication system is supplied to an inlet port in the pump body and an outlet port also in the pump body is provided for delivering oil metered from the pump to lubricate the engine's gas seals, there being provided a timing port in the pump shaft that alternately connects the inlet port and the outlet port with the chamber during each revolution of the pump shaft. The plunger is biased to stroke in a direction to contract the chamber and is permitted to retract by a cam formed on one end of the pump shaft that operates against this bias and determines the maximum plunger retracted position. Another cam which is controlled with the engine throttle operates to prevent the plunger from being biased past a stroke contracting position that increases as the engine throttle is opened. In one embodiment the plunger bias is provided by a simple lever which is pivoted at one end to the pump body and is biased to engage the plunger by a coil spring arranged between the lever and pump body. In another embodiment the bias on the plunger is provided by a simple cantilever beam arrangement with no additional spring bias required. With the pump shaft being driven at a speed proportional to engine speed and the stroke of the plunger increasing with increasing engine throttle opening, the pump displacement thus increases with increasing engine throttle opening and as a result oil is metered by the pump at a rate that increases with increasing engine speed and increasing throttle opening.

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

Another object is to provide a rotary engine oil metering pump of improved structure that meters oil at a rate that increases with increasing engine speed and increasing engine throttle opening.

Another object is to provide a rotary engine oil metering pump having a plunger that is carried by an engine driven pump shaft and is stroked according to a bias controlled by a cam on the pump shaft and also an engine throttle controlled cam to provide increasing pump displacement within increasing engine throttle opening.

Another object is to provide a rotary engine oil metering pump having a plunger that is carried by an engine driven pump shaft and is biased under the control of a cam on the pump shaft and also an engine throttle controlled cam to provide a volumetric displacement that increases with engine throttle opening and with such displacement effecting periodic oil delivery via a port in the pump shaft during each pump shaft revolution so that there is effected oil metering at a rate that increases with increasing engine speed and engine throttle opening.

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

FIG. 1 is an elevational view with parts in section of a rotary engine with an oil metering pump according to one embodiment of the present invention.

FIG. 2 is an enlarged elevational view of the oil metering pump in FIG. 1.

FIG. 3 is a view of the oil metering pump taken along the line 3—3 in FIG. 2.

FIG. 4 is a view of the oil metering pump taken along the line 4—4 in FIG. 2.

FIG. 5 is a view of the oil metering pump taken along the line 5—5 in FIG. 2.

FIG. 6 is an enlarged elevational view of another embodiment of the oil metering pump according to the present invention.

FIG. 7 is a view of the oil metering pump taken along the line 7—7 in FIG. 6.

FIG. 8 is a view of the oil metering pump taken along the line 8—8 in FIG. 6.

Referring to FIG. 1, there is shown a rotary combustion engine 10 having an oil metering pump 12 according to one embodiment of the present invention that meters oil to lubricate the engine's gas seals. The engine 10 comprises a stationary outer body or housing 13 having a rotor cavity that is defined by an inwardly facing peripheral wall 14 and a pair of opposed side walls 16, only one of which is shown. The peripheral wall 14 is in the shape of a two-lobe epitrochoid or a curve parallel thereto and a rotor 18 having the general shape of a triangle with three convex peripheral faces 20 is mounted within the rotor cavity on an eccentric 22 of a crankshaft 24 which is rotatably mounted outboard of the rotor cavity in the side walls 16. An annular externally toothed gear 26 is received about and is concentric with the crankshaft 24 and is rigidly secured to the engine housing 13. The gear 26 meshes with an internally toothed gear 28 that is concentric with and fixed to one side of the rotor 18. The gear 28 has one and one-half times the number of teeth as the gear 26 with the result that this gearing enforces a fixed cyclic relation between the rotor and the crankshaft such that the crankshaft which is the engine's output shaft makes three complete revolutions for every one complete revolution of the rotor. The rotor faces 20 cooperate with the peripheral wall 14 and with the side walls 16 to define three variable volume working chambers 30 that are spaced around and move with the rotor within the housing as the rotor orbits within the rotor cavity.

A carburetor 32 supplied with fuel from a fuel tank 34 by a fuel pump 36 delivers an air-fuel mixture to an intake manifold 38 under the control of the carburetor's throttle valve whose opening is controlled by a throttle lever 40 that is connected at one end to the throttle valve's shaft 41. The other end of lever 40 is

pivotaly connected to a rod 42 that is linked to an accelerator pedal, not shown, for control by the vehicle operator, the throttle valve arrangement being such that it is opened when the throttle lever 40 is pivoted in a counterclockwise direction as viewed in FIG. 1. The intake manifold 38 is connected in the engine housing 13 to deliver the air-fuel mixture to opposed intake ports 44, only one of which is shown, in the side walls 16. On rotor rotation in the direction indicated by the arrow in FIG. 1, air-fuel mixture is sequentially periodically admitted to the chambers 30 by the traversing motion of the rotor relative to the intake ports 44 whereafter the air-fuel mixture is trapped and then compressed in readiness for ignition. Sequential ignition of the air-fuel mixture in the chambers 30 is effected by two spark plugs 46 and 48 which receive timed ignition pulses from a distributor 50 whose shaft 52 is driven by the crankshaft 24, this drive being effected by a pinion 54 that is connected to the lower end of the distributor shaft and meshes with a worm gear 56 that is formed on the crankshaft 24. The two spark plugs 46 and 48 are on the side of the peripheral wall 14 opposite the side where the intake ports 44 are located and are peripherally spaced about so that the plug 46 is said to trail the other plug 48. The spark plugs 46 and 48 may be fired together or only one plug fired according to certain engine operating conditions as is well known in the art. With combustion, the peripheral wall 14 takes the reaction to force the rotor to continue rotating and eventually each working chamber following the expansion phase is exhausted during an exhaust phase to an exhaust manifold 58 via an exhaust port 60 that is open to the rotor cavity through the peripheral wall 14 and is periodically traversed by the rotor apexes.

Sealing of the chambers 30 is effected by apex seals 62 each of which extends the width of the rotor and is mounted at a rotor apex, corner seals 64 each of which is mounted in a rotor side at each rotor apex, and side seals 66 each of which is mounted in a rotor side and extends between pairs of corner seals with the corner seals each providing a sealing link between the adjacent ends of two side seals and one apex seal. The apex seals 62 are urged radially outward by spring means, not shown, to continuously engage the peripheral wall 14 and both the corner seals 64 and side seals 66 on both rotor sides are urged axially outward by suitable spring means, not shown, to continuously engage the side walls 16. In addition, there is provided a circular oil seal 68 mounted in a concentric groove in each rotor side that is biased axially outward by suitable spring means, not shown, to continuously engage the opposite side walls 16 to prevent oil that is used for lubrication of the crankshaft and other rotating parts from moving radially outward to the gas seals.

The oil metering pump 12 according to the present invention is well suited to metering oil for delivery to the rotary engine of the above type via a gas seal lubrication system like that described in copending U. S. application Ser. No. 271,785, 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 a pair of oil feed ports 70, only one of which is shown, that are located in the side walls 16. The oil feed ports 70 are located opposite each other at the same radial and angular locations relative to the crankshaft axis and close to and past the

side wall intake ports 44 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 side wall intake ports 44. With this arrangement the side wall oil feed ports 70 feed oil on to the side walls as the side seals sequentially wipe therepast after having wiped past the side wall intake ports. Most of the oil thus delivered is wiped across the side walls and the remainder is thrown by centrifugal force to lubricate the peripheral wall. For further details of such a gas seal lubrication system reference should be made to the aforementioned Casey patent application.

Describing now the embodiment of the oil metering pump whose details are shown in FIGS. 2 through 5, there is a two-piece housing comprising a pump body 72 and a cover 73 which are secured by two bolts 74 and 75 to the engine housing 13 with a cylindrical boss 76 on the pump body 72 fitting in a corresponding aperture 77 in the housing. Gaskets 78 and 79 are provided between the engine housing and pump body 72 and between the pump body 72 and cover 73 to prevent leakage between the respective parts. As shown in FIGS. 3 and 4, the pump body 72 has a bore 80 which extends therethrough including through the boss 76 at right angles to the distributor shaft 52. A pump shaft 82 is rotatably mounted in bore 80 and has a reduced diameter end which extends past the boss with this reduced diameter section having a pinion 83 pinned thereto which meshes with a worm gear 84 secured to the distributor shaft 52 at a location intermediate the distributor pinion 54 and the distributor 50. The pump shaft 82 is retained in bore 80 by a retainer 85 that is secured by a screw 86 to the inboard end of the pump body boss 76 and is received with running clearance in an annular groove in projecting portion of the shaft 82. As best shown in FIG. 4, the pump shaft 82 has bored from its large diameter end a cylinder 88 whose axis is coincident with that of the pump shaft. Closely fitted in cylinder 88 is a solid cylindrical piston or plunger 90 which is capable of reciprocal movement. The plunger 90 cooperates with the cylinder 88 to define an expandible chamber 91 that expands and contracts when the plunger is caused to reciprocate. A coil spring 92 located in chamber 91 acts on the inner end of the plunger 90 to urge it in an axial direction outward of the pump shaft which is rightward as viewed in FIG. 3 and downward as viewed in FIG. 4.

Reciprocation of the plunger 90 while the pump shaft 82 is rotating is effected by the outer end of plunger 90 engaging an intermediate portion 94 of a lever 95. Lever 95 is mounted for pivoting about an axis at right angles to the plunger axis by a pin 96 which is press-fitted in a hole 97 drilled in the pump body 72 crosswise of a recess 98 also in the pump body, this recess together with a recess 99 in the cover 73 forming a chamber 100 in which the lever 95 is housed. A coil spring 101 received about a boss 102 integral with the cover 73 engages the lever 95 between the intermediate portion 94 and the pin 96 to bias the lever clockwise as viewed in FIG. 4. The force on plunger 90 derived from spring 101 and the effective lever arm length is determined to be larger than the opposing force from spring 91 so that the spring biased lever 95 urges the plunger 90 into the cylinder 88 in what will be described as the contracting direction to decrease the volume of chamber 91. Expansion of chamber 91 is effected by the end of shaft 82 being provided with

an annular cam 103 about the cylinder 88 that is engageable with a portion 104 of the lever 95 radially outward of the plunger engaged portion 94. The pump shaft cam 103 has a minimum axial height 106 and a maximum axial height 108 of longer annular length. As the pump shaft turns, the cam at its maximum height 108 engages the lever portion 104 to force the lever 95 against the bias of spring 101 to a desired plunger limiting position during each pump shaft revolution to permit the plunger to stroke in what will be described as the expanding direction to but not past a non-variable maximum expanded position, as shown, in which condition the chamber 91 is at maximum volume. The profile of the cam is determined according to the direction of pump shaft rotation so that the cam 103 has a gradual slope 109, as best shown in FIG. 4, which forces a gradual movement of the lever 95 and thus permits gradual movement of the plunger 90 to its maximum expanded position and then has a steep slope 110, as best shown in FIG. 3, which permits the spring biased lever to force the plunger 90 from its maximum expanded position in the contracting direction into the cylinder 88 at an increasing rate to rapidly contract the chamber 91. Thus, the maximum chamber volume is non-variable or fixed. However, the plunger's maximum contracted position and corresponding minimum chamber volume is made variable and is controlled by a throttle controlled camshaft 111 that is mounted in a bore 112 of the pump body 72 offset from and at right angles to the plunger axis as best shown in FIGS. 4 and 5. Camshaft 111 is retained in its bore by a tongue 113 on the cover 73 received with clearance in an annular groove in the camshaft as shown in FIG. 5. Camshaft 111 has an eccentric 114 that is engageable with the lever 95 at a location adjacent and directly radially outward of the pump shaft cam engaged portion 104. With the camshaft 111 in the angular position shown in FIG. 4 which is the maximum lift position, it is radially aligned with the highest lift on the pump shaft cam 103 and by its engagement with the lever 95 prevents the lever from forcing the plunger 90 into the bore 88 as the pump shaft turns. However, when the camshaft 111 is turned through some angle, as will be discussed in greater detail later, the eccentric 114 then permits the lever 95 to follow the pump shaft cam 103 and effect movement of the plunger 90 in the contracting direction through a portion of a pump shaft revolution whereafter the plunger is returned to its maximum expanded position during the remaining portion of each revolution with the pump stroke and thus pump displacement increasing with increasing angular movement or turning of the camshaft 111.

The camshaft 111 is linked to the engine's throttle linkage so that it is turned to increase the pump stroke as the engine throttle is opened. Referring to FIGS. 1, 2 and 5, a lever 115 is splined at one end to the outboard end of the camshaft 111 and retained thereon by a screw 116. The other end of lever 115 has a hole receiving the bent end of a rod 117 which is retained by a friction washer 118 as shown in FIG. 2. The rod 117 is similarly connected at its other end as shown in FIG. 1 to a lever 120 which is pivotally supported on the carburetor's throttle valve shaft 41 and is engaged by a tang 121 on the throttle lever 40 to pivot counterclockwise to pull the rod 117 and thus turn the pump's camshaft 111 clockwise as viewed in FIG. 4. As shown in FIG. 2, an adjustable stop provided by a stop screw 122

threaded to a tang on the pump lever 115 engages a stop pad 124 formed on the pump body to determine the pump's minimum displacement condition. The lever 115 and thus the camshaft 111 is biased to this stop position by a torsion spring 125 which as shown in FIGS. 2 and 5 is arranged about the boss for the camshaft 111 and engages at its opposite ends the pump body 72 and lever 115 so that its force urges counterclockwise movement of the lever as viewed in FIG. 4. In the minimum pump stroke condition with the lever 115 against the stop 124, the camshaft 111 is positioned to limit counterclockwise pivoting of plunger lever 95 as shown in FIG. 4 and thus limit the contracting stroke of the plunger 90. Then as the lever 115 is pivoted with opening of the engine throttle, the camshaft 111 is turned to angulate the eccentric 114 to permit the lever 95 to pivot through a larger angle and thereby increase the stroke of plunger 90 and thus the displacement of the pump with such increase continuing until the full engine throttle condition is reached.

Describing now how oil is supplied to the pump 12, metered and then delivered to the oil feed ports 70 to lubricate the engine's gas seals, oil is obtained from the engine's pressurized lubrication system which includes a drilled passage 127 in the engine housing 13 that aligns with a passage 128 in the pump body 72 on assembly of the metering pump to the engine as shown in FIG. 4. The passage 128 in the pump body includes a filter 129 that filters the oil prior to its reaching a drilled passage 130 that intersects at the interface of the pump body 72 and cover 73 with a drilled passage 131 that extends parallel to the pump body bore 80 as shown in FIG. 3. The pump chamber 91 is connected by a drilled radial passage 132 to an annular extending timing port 134 that extends less than half-way around the pump shaft 82. The timing port 134 is periodically registerable on pump shaft rotation with an inlet port 136 and then an outlet port 137 which intersects the bore 80 at diametrically opposite locations. The ports 136 and 137 are drilled in the same operation through a hole which is later plugged by a screw 138. The inlet port 136 intersects the oil supply passage 131 and the oil outlet port 137 is connected via a drilled passage 139 with a nipple 140 that is press-fitted to the pump body cover 73 and is connected via a hose 141 to deliver oil to the oil metering ports 70 in the engine side walls 16. The timing port 134 is generally located at right angles to the minimum and maximum lift points on the pump shaft cam 106 and relative to the direction of pump shaft rotation so that with oil supply to the inlet port 136 and with the pump shaft 82 driven by the engine and turning clockwise as viewed in FIG. 2, the timing port 134 is open to the inlet port 136 as the plunger 90 is moving in its expanding direction so that the chamber 91 is charged with oil as it expands. Then on continued pump shaft rotation and within the same pump shaft revolution and as the plunger 90 is caused to extend into the cylinder 88 by the spring biased lever 95, the timing port 134 is closed off from the inlet port 136 and is opened to the outlet port 137 so that oil is then discharged from the pump and delivered to the oil feed ports 70 to lubricate the engine's gas seals. Thus, oil is supplied to the chamber 91 as it expands and is forced therefrom and delivered to lubricate the gas seals as it contracts for each turn of the pump shaft with the amount of oil thus delivered during each revolution determined by the then existing displacement of the

chamber 91. Thus, oil is metered to the outlet port 137 at a rate that increases with both increasing pump shaft speed which is proportional to engine speed and increasing pump displacement which is proportional to engine throttle opening and thus engine torque demand. It will be understood that the oil may also be supplied to the pump by gravity feed instead of under pressure and that the plunger spring 92 may be eliminated where there is forced oil supply or where the pump is arranged so that gravity operates to urge the plunger on its expansion stroke.

In the embodiment in FIGS. 2, 3, 4 and 5, the lever 95 is a rigid part which may be made at low cost of stamped sheet metal, as shown, and is biased by a separate spring. It is also possible to provide the same type of pump operation with less parts as shown by the embodiment in FIGS. 6, 7 and 8. In the latter embodiment, there is provided a similar arrangement of pump body 172, cover 173, pump shaft 182 driven by the engine and carrying plunger 190, and throttle controlled camshaft 211 with cam 214 operated through lever 215 with the engine throttle linkage. However, instead of a lever biased by a spring to effect plunger movement there is provided a single spring member 220 in the form of a cantilever beam that is constructed from wire and has a loop at one end that provides for securing the beam by a screw 221 to the pump body 172. The spring member 220 has a flattened portion 222 that provides a beam section to the desired spring characteristic and then returns to its wire diameter throughout the remainder of its length which includes a portion 224 which is aligned to engage the outboard end of the plunger 190. The spring member 220 thereafter has two right angle bends to present a portion 26 at the free end that is generally at right angles to and engages both the pump shaft cam 203 and the throttle controlled cam 214. The pump shaft cam 203 operates on the wire portion 26 to bend spring member 220 to move plunger 190 upward as viewed in FIG. 7 during part of one pump shaft revolution and permits the force in this spring member to push the plunger back into the cylinder with the plunger stroke determined by the spring section 226 engaging the throttle controlled cam 214. In all other respects, this embodiment is like the embodiment in FIGS. 2 - 5 with oil supplied via inlet port 236 and timing port 234 to chamber 191 and then via the timing port to outlet port 237 during each pump shaft revolution.

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 having gas seals, an output shaft and a throttle, an oil metering pump comprising a pump body having a bore, a pump shaft rotatably mounted in said bore, means drivingly connecting said output shaft to rotate said pump shaft, said pump shaft having a central axially extending cylinder in one end thereof, a plunger mounted in said cylinder, said plunger and said cylinder cooperatively defining a chamber in said pump shaft whose volume varies when said plunger 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 for delivering oil from said chamber to lubricate said gas seals, a timing port in said pump

shaft for alternately connecting said inlet port and said outlet port to said chamber during each revolution of said pump shaft, plunger biasing means comprising a lever pivotally mounted on said pump body and engageable with said plunger and a spring acting on said lever for biasing said plunger to stroke in said plunger contracting direction to decrease chamber volume, said pump shaft on said one end having an annular cam about said cylinder for moving said lever against the bias of said spring to a plunger limiting position during each revolution of said pump shaft to permit said plunger to stroke in said expansion direction to but not past a non-variable maximum expanded position determined by engagement of said plunger with said plunger biasing means to thereby determine a non-variable maximum chamber volume condition, said pump shaft cam having maximum and minimum lift heights angularly spaced with respect to said timing port and the direction of pump shaft rotation so that said timing port connects said inlet port and said chamber when said plunger is moving in said expanding direction and connects said outlet port and said chamber when said plunger is moving in said contracting direction, a throttle controlled cam mounted in said pump body for engaging said lever to prevent said spring biased lever from biasing said plunger in said contracting direction past a variable maximum contracted position that varies in distance from said non-variable maximum expanded position as said throttle controlled cam is turned, and means operatively connecting said throttle to turn said throttle controlled cam to increase the distance between said variable maximum contracted position and said non-variable maximum contracted position as said throttle is opened and thereby increase plunger stroke and volumetric displacement with increasing throttle opening whereby oil is metered from said inlet port to said outlet port for gas seal lubrication at a rate which increases with increasing output shaft speed and increasing throttle opening.

2. A rotary engine having gas seals, an output shaft and a throttle, an oil metering pump comprising a pump body having a bore, a pump shaft rotatably mounted in said bore, means drivingly connecting said output shaft to rotate said pump shaft, said pump shaft having a central axially extending cylinder in one end thereof, a plunger mounted in said cylinder, said plunger and said cylinder cooperatively defining a chamber in said pump shaft whose volume varies when said plunger 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 for delivering oil from said chamber to lubricate said gas seals, a timing port in said pump shaft for alternately connecting said inlet port and said outlet port to said chamber during each revolution of said pump shaft, plunger biasing means comprising a spring member rigidly secured at one end to said pump body and engageable with said plunger for biasing said plunger to stroke in said plunger contracting direction to decrease chamber volume, said pump shaft on said one end having an annular cam about said cylinder for moving said spring member to a plunger limiting position during each revolution of said pump shaft to permit said plunger to stroke in said expanding direction to but not past a non-variable maximum expanded position determined by engagement of said plunger with

said spring member to thereby determine a non-variable maximum chamber volume condition, said pump shaft cam having maximum and minimum lift heights angularly spaced with respect to said timing port and the direction of pump shaft rotation so that said timing port connects said inlet port and said chamber when said plunger is moving in said expanding direction and connects said outlet port and said chamber when said plunger is moving in said contracting direction, a throttle controlled cam mounted in said pump body for engaging said spring member to prevent said spring member from biasing said plunger in said contracting direction past a variable maximum contracted

position that varies in distance from said non-variable maximum expanded position as said throttle controlled cam is turned, and means operatively connecting said throttle to turn said throttle controlled cam to increase the distance between said variable maximum contracted position and said non-variable maximum contracted position as said throttle is opened and thereby increase plunger stroke and volumetric displacement with increasing throttle opening whereby oil is metered from said inlet port to said outlet port for gas seal lubrication at a rate which increases with increasing output shaft speed and increasing throttle opening.

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