United States Patent [19]

Green et al.

[11] **3,929,117**

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[54] **ROTARY ENGINE OIL TANK VENT**

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

[22] Filed: **Oct. 29, 1974**

[21] Appl. No.: **518,574**

[52] **U.S. Cl.** ..... **123/196 R;** 123/8.01; 184/6.5; 418/83

[51] **Int. Cl.²** **F01M 1/10**

[58] **Field of Search** ..... 418/83, 88, 94; 123/8.01, 123/41.86, 196 R, 196 CP; 184/6.5, 6.16, 106; 180/69.1

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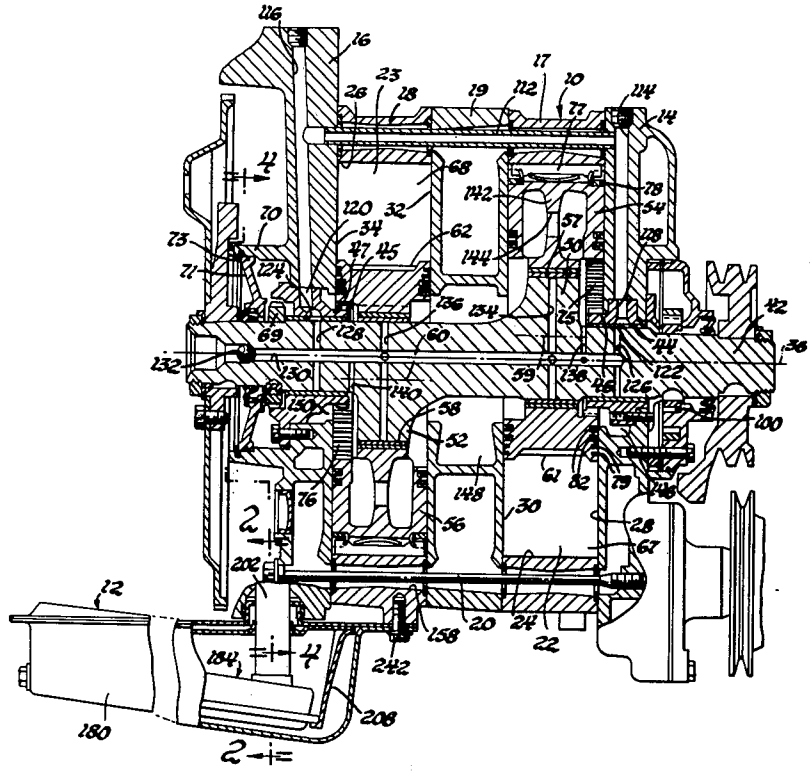
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Primary Examiner—William L. Freeh
Assistant Examiner—Leonard Smith
Attorney, Agent, or Firm—Ronald L. Phillips

[57] **ABSTRACT**

An end cover for normally covering the outboard end of an end housing in a rotary engine has a wall forming a cavity that is shielded from engine oil to provide an elevated quiet zone to which air is vented internally from the top of the engine's oil tank and thence into the engine's internal breathing system.

2 Claims, 7 Drawing Figures



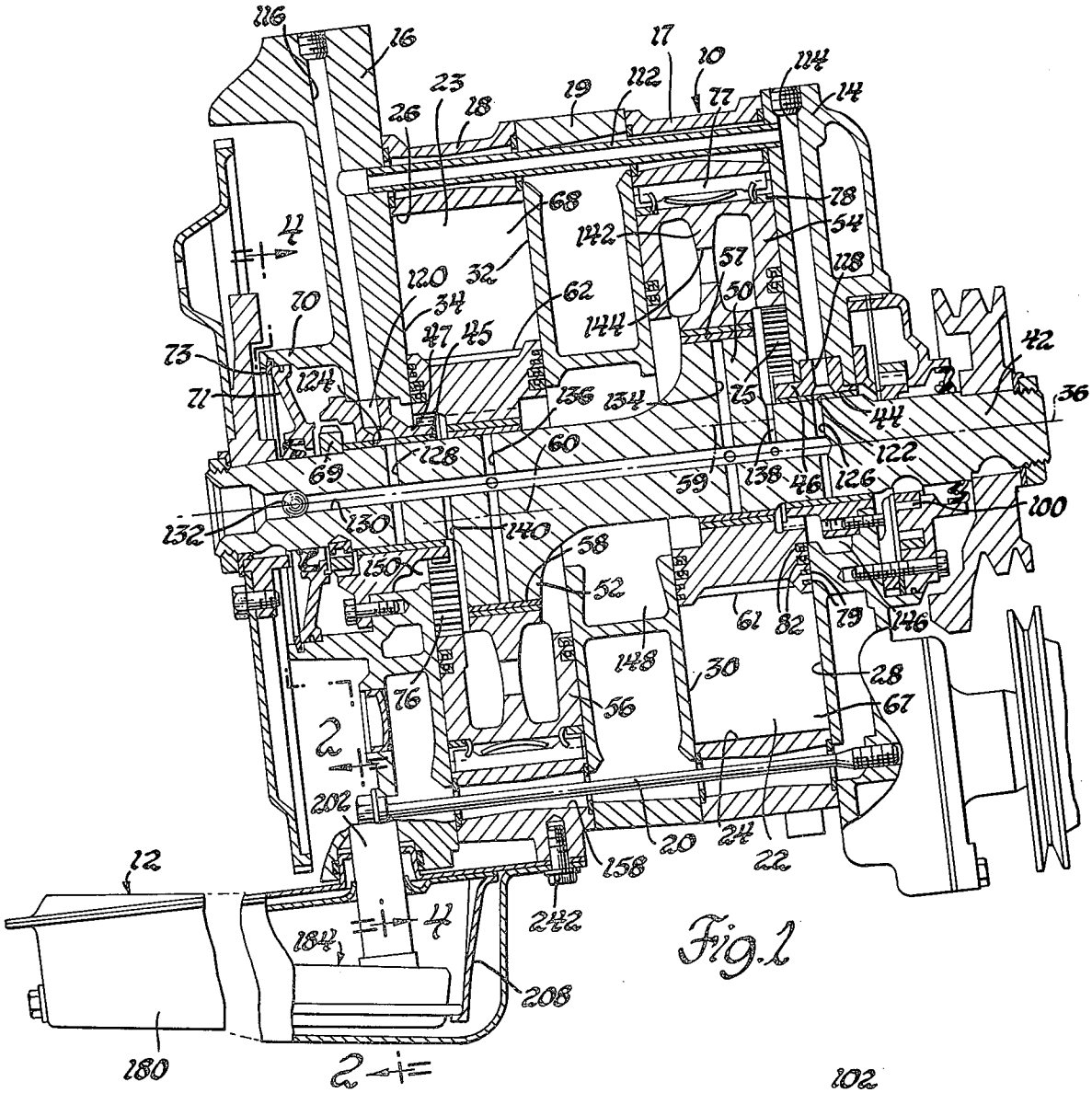

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Fig. 1

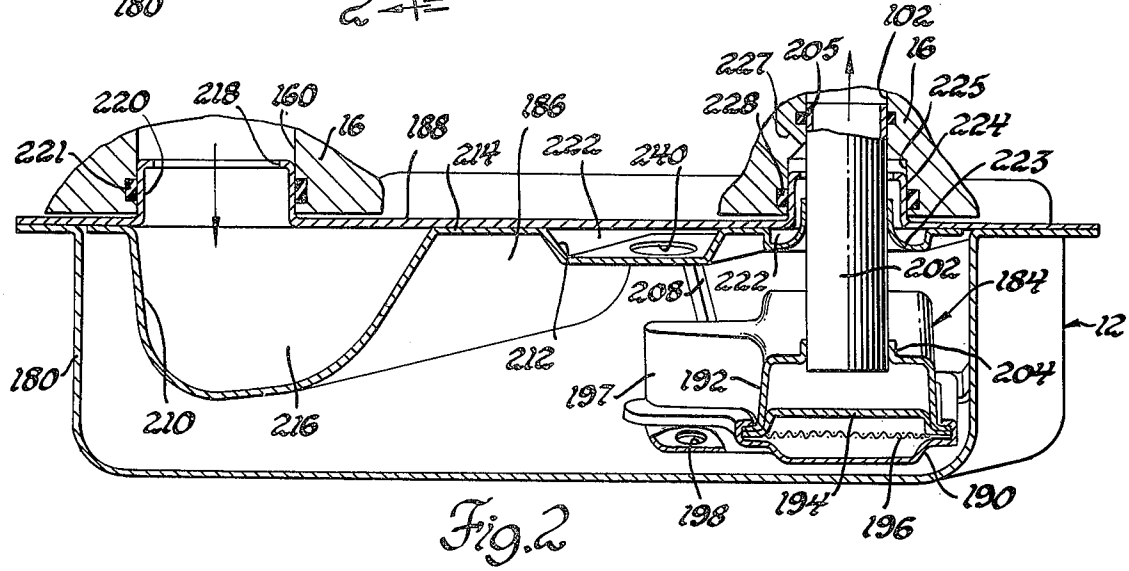

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Fig. 2

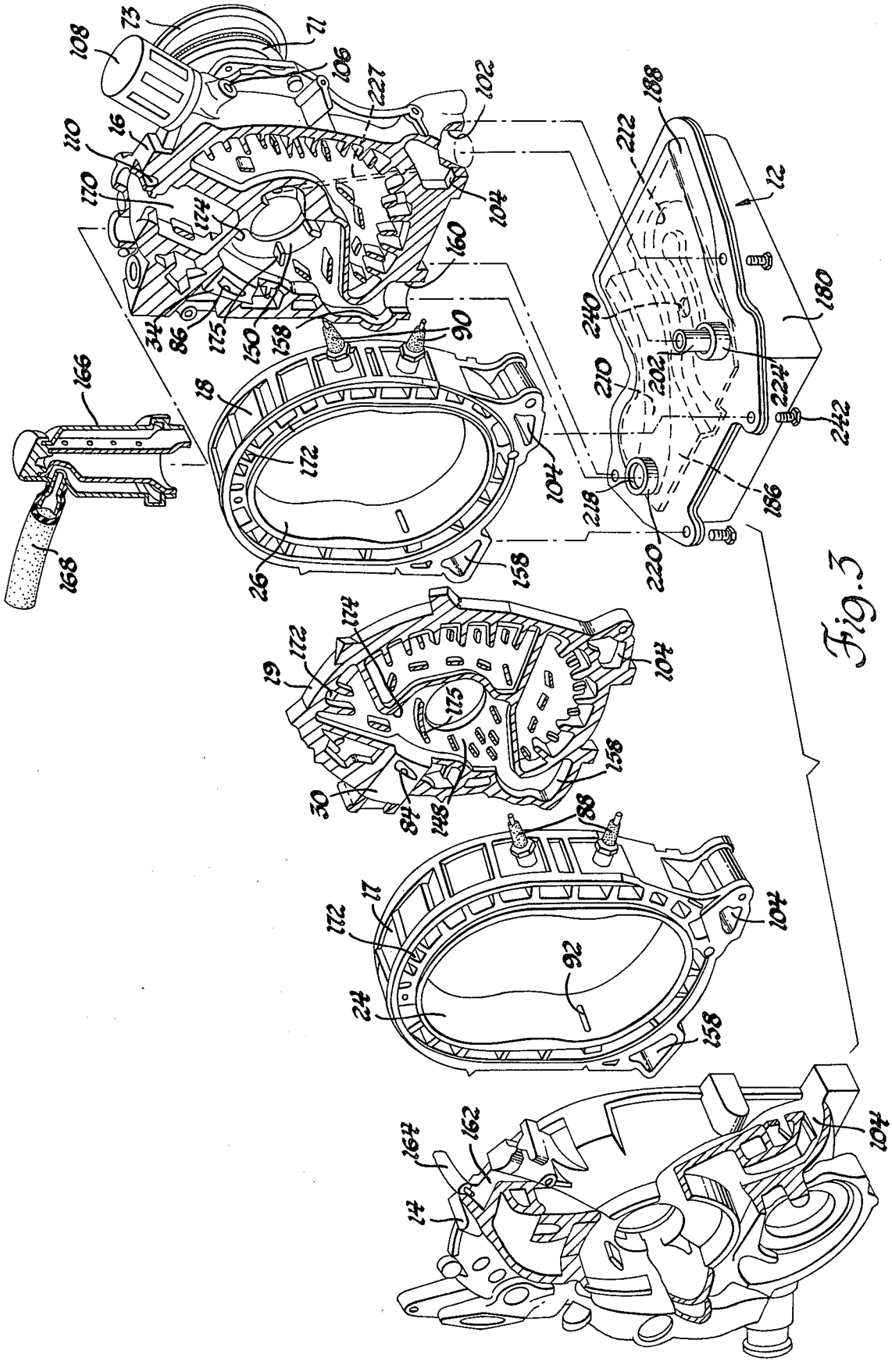

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Fig. 3

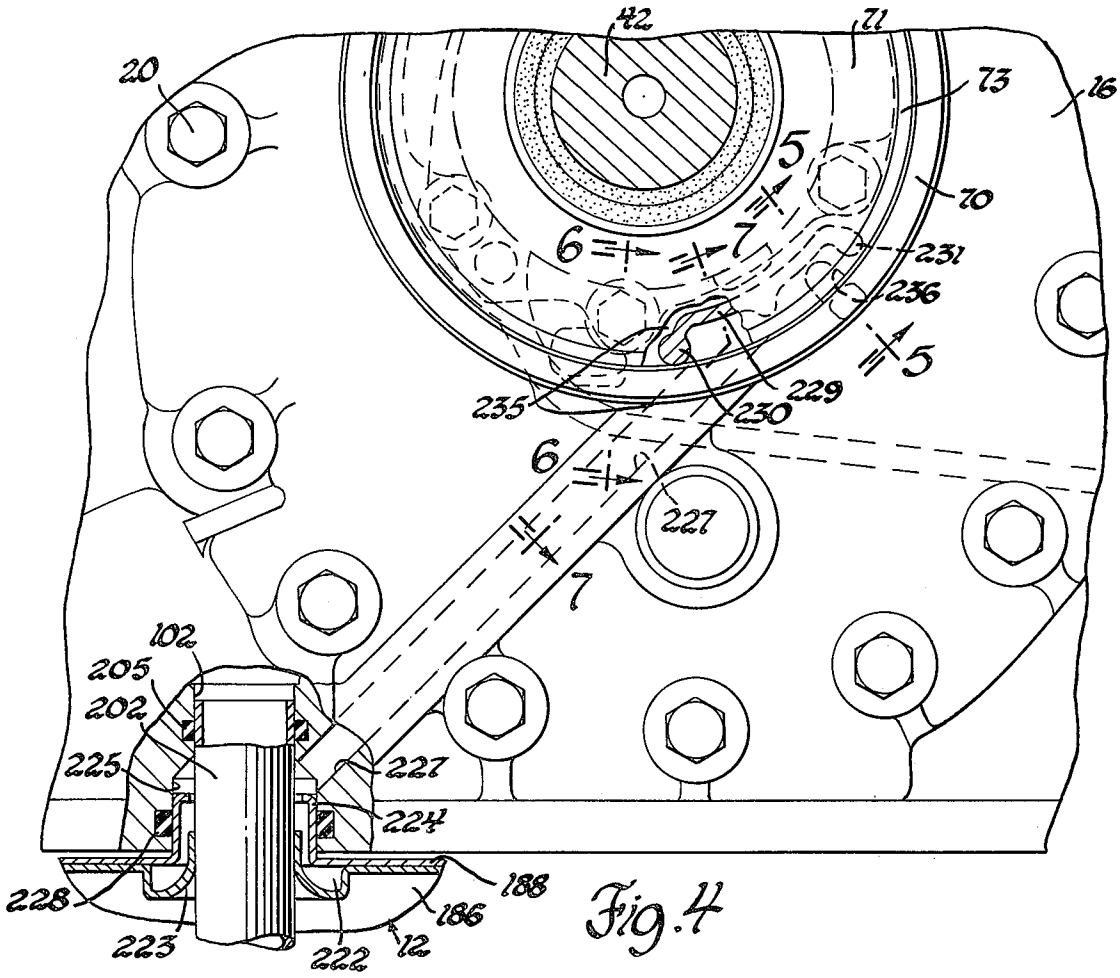


Fig. 4

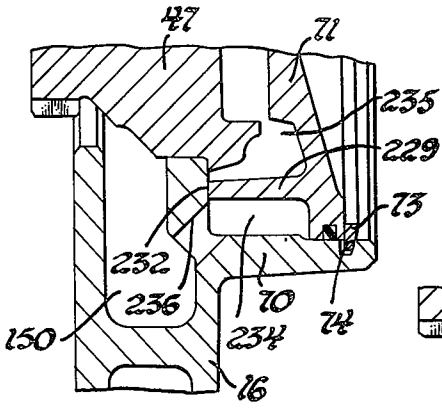


Fig. 5

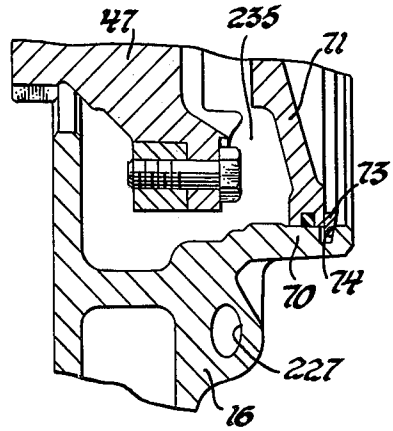


Fig. 6

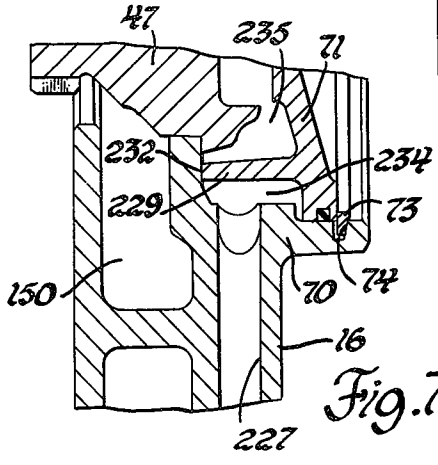


Fig. 7

ROTARY ENGINE OIL TANK VENT

This invention relates to a rotary engine oil tank vent and more particularly to such a vent that is provided in an elevated position internally of the engine by cooperation between an end housing and an end cover.

In rotary engines having an oil tank that is closed at its top except for a suction passage to the pump and a drain passage from the engine, the interior of the tank above the oil level may have to be vented other than just through the drain passage to assure adequate drainage thereto from the engine. One obvious solution is to attach an external vent tube to the top of the oil tank. However, this tube is subject to possible damage and leakage could then be external of the engine. Thus, substantial advantages can be gained if an additional oil tank vent can be provided internally of the engine particularly if this can be accomplished simply and economically and without substantially disturbing existing engine structure.

According to the present invention there is provided a rotary engine oil tank vent arrangement wherein an existing end cover that normally covers the outboard end of an end housing is modified so as to form with the end housing a quiet or undisturbed zone that is in an elevated position in the engine above the oil tank. The top of the oil tank is open to the engine drain and, in addition, is vented to this quiet zone through an annular passage formed about a suction pipe that delivers the oil in the tank to the engine's oil pump. This quiet zone is shielded from any oil that normally collects close by in the end housing and the air vented from the oil tank and delivered thereto is directed from there into a passage that opens to the engine's breathing system at a further elevated position. As a result, air in the oil tank is not restricted in its ability to get out and thus good drainage to the oil tank is assured and without external vent tubing and the like.

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

Another object is to provide in a rotary engine an elevated internal quiet zone provided by simple modification of existing parts with air vented internally from the tank to the quiet zone and then directed by this quiet zone at a further elevated position in the engine's internal breathing system.

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

FIG. 1 is a side elevational view with parts in section of a rotary engine having an oil tank with an air vent constructed according to the present invention.

FIG. 2 is an enlarged view taken along the line 2—2 in FIG. 1.

FIG. 3 is an exploded view of certain of the engine parts.

FIG. 4 is an enlarged view taken along the line 4—4 in FIG. 1.

FIG. 5 is a view taken along the line 5—5 in FIG. 4.

FIG. 6 is a view taken along the line 6—6 in FIG. 4.

FIG. 7 is a view taken along the line 7—7 in FIG. 4.

Referring to FIGS. 1, 2 and 3, there is shown a two-rotor rotary engine 10 with an oil tank 12 vented according to the present invention and as installed in a vehicle. The engine 10 has an outer body comprising a pair of end housings 14 (front) and 16 (rear), 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 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 front end housing 14 and intermediate housing 19 and the latter housing and rear 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 extends through the cavities 22 and 23 and is rotatably supported in main bearings 44 and 45 which are fixed in stationary gears 46 and 47 that are bolted to the respective housings 14 and 16 as shown in FIG. 1, 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 housing cavities 22 and 23 with eccentrics 50 and 52 on which hollow rotors 54 and 56 having bearings 57 and 58 are mounted for rotation about the eccentric centers 59 and 60, these centers 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 61 and 62 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 and move with the respective rotors within the engine housing.

Near the rear end of crankshaft 42 outboard of stationary gear 47, a distributor drive gear 69 is secured thereto and the rear end housing 16 has an annular rearwardly extending projection 70 about this gear. An annular end cover 71 is received about this end of the crankshaft and fits into the projection 70 to close off the center of the engine at this end, the end cover having a lip seal at its inner diameter that contacts the crankshaft and being retained at its outer diameter which is sealed by an O-ring by a tapered snap ring 73 that fits in a radially inwardly facing groove 74 in the end housing projection 70.

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 the stationay gear 46 which is fixed to the housing and is received about and is concentric with the crankshaft 42. The gear 46 meshes with an internal tooth gear 75 that is concentric with and formed on the outboard side of rotor 54. The gear 75 has 1½ times the number of teeth as the gear 46 with the 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. Similarly, the other stationary gear 47 meshes with an internal tooth gear 76 on the other rotor 56 with their mesh at a location diametrically opposite that of gears 46 and 75. Thus, the chambers 67 and 68 move with the respective rotors 54 and 56 as they revolve about their axes while also revolving about the crankshaft axis with each chamber twice undergoing expansion and contraction during each rotor revolution.

Sealing of the working chambers such as the working chambers 67 is effected by three apex seals 77 each of which extends the width of the rotor and is mounted in an axially extending slot at one of the rotor apexes, six corner seals 78 each of which is mounted in a hole in one of the rotor sides near one of the rotor apexes, and 12 side seals 79 each of which is mounted in an arcuate

groove in one of the rotor sides with these seals arranged in pairs and extending 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 pairs of side seals. The apex seals **77** are each spring biased radially outward to continuously engage the peripheral wall **24** and both the corner seals **78** and the side seals **79** in both rotor sides are spring biased axially outward to continuously engage the respective end walls **28** and **30.** In addition, there is mounted in grooves in each rotor side inward of the side seals **79** a pair of spring biased circular oil seals **82** which are concentric with the rotor and sealingly engage the opposite end wall to prevent oil from reaching further outward. The rotor **56** carries a similar gas and oil seal arrangement.

A combustible air-fuel mixture is delivered by an induction system, not shown, that includes a carburetor that is mounted on an intake manifold. The intake manifold is connected to the engine housing and has branches that communicate in the engine housing with intake ports **84** and **86** in the respective housing end walls as shown in the end walls **30** and **34** in FIG. **3.** Upon rotor rotation the combustible air-fuel mixture is sequentially, periodically admitted to the chambers **67** and **68** as they are expanding by the traversing motion of the rotor sides relative to the respective intake ports 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 suitable ignition system having a distributor driven by drive gear **69.** The ignition system applies voltage at the proper time to pairs of spark plugs **88** and **90** which are mounted on the rotor housings, as shown in FIG. **3,** with their electrodes open to the combustion chambers through the respective peripheral walls. For example, the electrodes of the two spark plugs **88** mounted on front rotor housing **17** are open to the chambers **67** through the interior peripheral wall **24** and are peripherally spaced thereabout so that one plug leads the other plug relative to rotor rotation. In such an arrangement both plugs are fired at the same time or different times or only one plug is 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 by an exhaust port **92** in the peripheral wall **24** that is periodically traversed by the rotor apexes and is open to an exhaust manifold secured to the exterior of the engine housing.

Describing now the lubrication system but deferring the details of the oil tank and its vent until later, oil is drawn from the oil tank **12** by an oil pump **100** through a suction hole **102** in the bottom of the rear end housing **16** and thereafter passes forwardly to the front end housing **14** where the oil pump is mounted via a horizontal passage **104** formed in the housings **16, 18, 19, 17** and **14** as shown in FIG. **3.** The oil pump **100** is of the internal-external gear type and is mounted about and is driven by the crankshaft **42** as best shown in FIG. **1.** Oil pump **100** delivers the oil under pressure to an external cooler, not shown, from which the oil is then directed to a passage **106** in the rear housing shown in FIG. **3.** Passage **106** delivers the oil to an oil filter **108** that is mounted on the rear end housing and from the filter, oil is delivered to a distribution passage **110** with the pressure feed to the cooler and also the distribution pressure in the engine controlled by suitable pressure regulator valves, not shown, such as disclosed in copending U.S. patent application Ser. No. 432,848, filed Jan. 14, 1974 and assigned to the assignee of this invention. The pressure distribution passage **110** runs into an oil gallery tube **112,** shown in FIG. **1,** that passes through a passage in the top of the rotor housings **17** and **18** and intermediate housing **19.** Tube **112** joins at its opposite ends in the front and rear end housings **14** and **16** with long drilled holes **114** and **116,** respectively, that run from the gallery downward toward the center of the housings and stationary gears **46** and **47.** Oil is forced into the crankshaft at each end through respective holes **118** and **120** in the front and rear stationary gears **46** and **47,** radial holes **122** and **124** in the front and rear main bearings **44** and **45** and radial holes **126** and **128** in the crankshaft **42** to a long central feed hole **130** in the crankshaft that is drilled from the rear end thereof and then plugged by a press-fitted ball **132.** Thus, the main bearings **44** and **45** are fed with oil for lubrication and, in addition, radial holes **134** and **136** connect the central feed passage **130** to feed oil to the rotor bearings **57** and **58** for their lubrication. In addition, radial orifices **138** and **140** connected to the central feed passage **130** direct oil radially outwardly between the phase gears **46, 75** and **47, 76** and eccentrics **50** and **52,** respectively, to lubricate the phase gears and also to pass into the interior of the respective rotors **54** and **56** to effect their cooling. The rotors each have an internal web **142** with holes **144** to provide for circulation therethrough in an axial direction with the oil then exiting outwardly of the rotor and into cavities **146** and **148** in the front and intermediate housings **14** and **19** in the case of rotor **54** and into the intermediate housing cavity **148** and a cavity **150** in the rear end housing **16** in the case of rotor **56.** Oil in the pressurized distribution passage **110** is also delivered to an oil metering pump, not shown, which meters oil at a suitable rate to lubricate the rotors' gas seals. This oil metering pump may be of the type disclosed in copending U.S. patent application Ser. No. 357,072, filed May 3, 1973 and assigned to the assignee of this invention and may be connected to meter oil to mix with the fuel in the carburetor or to oil feed ports in the housing walls on which the seals slide.

The oil after leaving the main bearings, rotor bearings, phase gears and rotor cavities, falls through the cavities **146, 148** and **150** to a horizontal drain passage **158** that extends through the housings as shown in FIGS. **1** and **3.** The oil then drains to the oil tank **12** through a drain-vent hole **160** in the rear housing **16** as best shown in FIGS. **2** and **3.** Air is vented internally in the engine by a continuous air flow which is effected by the provision of a breather passage **162** in the front end housing **14** which is connected by a hose **164** to pull air from the engine's air cleaner and the provision of an air-oil separator **166** which is mounted on the rear housing **16** and is connected by a hose **168** and a PCV valve, not shown, to a vacuum zone in the carburetor. The separator **166** has a construction which is operative to permit air to be pulled from a top cavity **170** in the rear housing to the carburetor while separating out and draining oil to the drain cavity **150.** In this internal air flow system there are three parallel air paths through the housings, namely the drain passage **158** which carries air along with the oil from the front end housing to the oil tank **12,** an upper vent passage **172**

that can carry air from either the front housing breather cavity **162** to the rear end housing vent cavity **170** or in the reverse direction to compensate for the air carried from the oil drain passage and a third passage which is through the hollow rotors. In addition, the upper vent passage, the rotor vent passage and the drain passage are connected in the front, intermediate and rear housings for cross-flow and pressure equilization as shown in FIGS. **1** and **3.** These connecting passages in the front, intermediate and rear housings are provided with configurations **174** and deflectors **175** as shown on the intermediate and rear housings in FIG. **3** which act to prevent oil splash up into the vent passage **172** and to the air-oil separator **166.** Furthermore, any combustion gas blowby from the rotors through the connecting passages in the front, intermediate and rear housings is thus free to move up to the vent passage **172** through the air-oil separator **166** and the PCV valve out to the carburetor.

The oil tank **12** which is vented internally of the engine in accordance with the present invention as described in detail later comprises a stamped sheet metal pan **180** that is formed to provide a deep reservoir which is generally rectangular in cross-section as best seen in FIG. **2** and is boot-shaped in a horizontal plane or plan view as best seen in FIG. **3,** this boot-shape providing the maximum volume in a certain confined space in the vehicle. A cover or top assembly fits into and over the pan **180** and comprises a screen and suction pipe subassembly **184,** a stamped sheet metal inner cover **186** and a stamped sheet metal outer cover or top **188.**

The screen and suction pipe subassembly **184** comprises three pan-shaped sheet metal stampings; namely, a bottom piece **190,** a top piece **192** and an anti-drain-back inner wall piece **194** as shown in FIG. **2.** A screen **196** of suitable size mesh is arranged between the concave sides of the bottom **190** and the inner wall **194** and the concave side of the top **192** is deeper and arranged over the convex side of the inner wall. These sheet metal pieces have abutting peripheral flanges which are secured along their length by rolling over the bottom member's flange which is extended for that purpose. These parts are elongated to extend almost the length of the tank and have a transverse extending projection **197** as shown in FIG. **2** to locate an intake hole **198** in the bottom of this projecting portion in the center of the oil pool. The intake hole **198** is elevated at a minimum height by bumps, not shown, that project upwardly from pan **180** and engage the bottom of subassembly **184.** Oil after being drawn into the intake hole **198** passes through the screen **196** and then through a hole, not shown, in the inner wall **194** near the rear end thereof and then between the inner wall and the top **192** to the lower end of a vertical suction pipe **202** which projects through and is welded to a collar **204** formed on the top near the front end thereof. The upper end of suction pipe **202** is received by the engine's suction hole **102** and an O-ring **205** is provided to seal this connection as shown in FIGS. **2** and **4.**

The screen and suction pipe assembly **184** is secured to the underneath side of the inner cover **186** by three straps **208** which at their lower end are welded to the underside of the bottom piece's flange and at their upper end are welded to the underside of the inner cover. The top side of the inner cover **186** has a pair of channels **210** and **212** formed therein and a remaining planar portion **214** which is sealed by a suitable sealing compound and then welded to the underside or ceiling of the outer cover **188.** The channel **210** is relatively deep and wide and in cooperation with the ceiling of the outer cover **188** provides a longitudinal drain-vent passage **216.** Passage **216** is open at one end to a drain-vent hole **218** provided by a vertical tubular portion **220** which is formed on the top side of the outer cover **188** near the front end and fits closely in the engine's drain-vent hole **160** with an O-ring **221** provided to seal this connection of the oil tank with the engine. The drain-vent passage **216** extends to the rear end of the inner cover **186** to open to the reservoir near the rear end thereof. A U-shaped vent passage **222** is provided by the other channel **212** which extends at one end as an annulus about a vertical tubular portion **223** which is formed on the top side of the inner cover **186** near the front end and projects with clearance up into a tubular portion **224** which is formed on top of the outer cover **188.** The tubular portion **224** projects up into close fitting relationship with an enlarged portion **225** of the engine's suction hole **102** as shown in FIG. **2.** The suction pipe **202** extends up through tubular portions **223** and **224** to fit close in the engine's suction hole **102** and these tubular parts are sized to leave an annular clearance between the tubular portions **223** and **224** of the inner and outer covers and also between the tubular portion **224** and suction pipe **202** and no clearance between the inner cover's tubular portion **223** and the suction pipe so that there is sealing engagement between these latter two parts.

A vent hole **227** meets with the enlarged hole portion **225** above the outer cover's tubular portion **224** as shown in FIGS. **2** and **4** and thus provides a vent access for the passage between suction pipe **202** and the outer cover's tubular portion **224,** there being provided an O-ring **228** to seal this connection of the oil tank with the engine. To assure good venting, it is required that the vent hole **227** be connected to the engine's internal breathing system via a quiet or undisturbed zone in an efficient manner. This is accomplished according to the present invention by simply forming a shield or wall **229** integral with the inboard side of end cover **71** that extends a substantial circumferential distance and then turns radially outward at its two ends **230** and **231** as shown in FIG. **4.** The ends **230** and **231** are machined to have a close fit with the inner diameter of the end housing projection **70** and are at different elevations. In addition, the wall **229** has an end face **232** which is forced tight against a flat on the rear end housing **16** outward of the stationary gear **47** with the snap ring **73** installed as shown in FIGS. **5** and **7.** As a result, there is formed a cavity **234** of varying elevation within the oil supplied annular cavity **235** in which the distributor drive gear **69** is located and it is to the lower end of cavity **234** that the vent hole **227** is connected near the wall end **230** as shown in FIGS. **4** and **7.** The upper end of cavity **234** near wall end **231** is connected as shown in FIGS. **4** and **5** via a transverse vent hole **236** in the rear end housing **16** to an elevated portion of the drain cavity **150** in this housing which is away from the path of oil drainage, the drain cavity being in turn open at its top to the top vent cavity **170.** As shown in FIG. **6,** the cavity **235** with the distributor drive gear **69** drains cavity **150** and the vent connection is thus well above this drainage. Thus, air is allowed to freely escape from the oil tank into the engine's breathing system by the quiet or undisturbed zone **234** which is shielded by end cover wall **229** from any oil that collects behind station-

ary gear **47** and about distributor drive gear **69** and by means of this cavity and the transverse vent hole **236** there is also created a labyrinth that makes it difficult for oil to enter this vent passage.

The oil tank channel **212** is shallow at its thus vented front end and gradually increases in depth as it extends rearward with a downward slope along the underneath side of the outer cover to a location near the rear end of the reservoir and then turns and extends forward still with a downward slope to a hole **240** at the center of the oil tank and above the normal oil level that occurs with shifting of the oil level during engine operation with the vehicle either accelerating, decelerating or turning. The channel **212** thereafter continues at a relatively constant depth to the front end of the inner cover where it opens to the reservoir.

The pan **180** has a peripheral flange which is welded to the underneath side of the outer cover **188** along its periphery and the oil tank is secured to the engine by means of four holes which extend through the pan **180** and outer cover **188** and receive bolts **242** as shown in FIGS. **1** and **3** with two of these bolts engaging the rear rotor housing **18** and the other two bolts engaging the rear end housing **16.**

Describing now the oil flow to and from the oil tank **12** and the venting of the oil tank that is thus provided, oil is drawn through the suction hole **198** then through the screen **196** to the rearwardly located hole in the inner wall **194** whereafter it passes forward and then up through the suction pipe **202** to the engine's lubrication system while an equal flow from the engine's internal drain system drains to the engine's drain-vent hole **160** where it then passes through the oil tank's drain-vent hole **218** and is conveyed in the oil tank by the drain-vent passage **216** to replenish the oil reservoir. This returning oil carries with it a substantial amount of air trapped in the form of foam which must be removed from the closed oil tank to allow the oil to continue to return. This air is vented in part by making the drain-vent connection as large as practical to allow air to back up through the same hole it came down. To overcome any impedance to the venting, air from the top of the tank is also allowed to vent through the vent passage **222** to vent hole **227** with the downward slope of this passage causing oil that is pulled in with the air to drain out through the hole **240.** Vent air passes up through hole **227** to the elevated quiet zone **234** and from there out the hole **236** to an elevated zone in the engine's breathing system which has the air circulating to the engine's intake. Since this oil tank vent connection is out of the way of draining oil, there is no tendency for it to clog with oil and therefore the air in the oil tank has unrestricted ability to get out and permit easy entry of the draining oil through drain-vent hole **218.** It will also be appreciated that the drain hole **240** is located at the center of the tank and above the highest normal oil level so that this vent is always open to the interior of the oil tank above the oil level.

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

We claim:

1. A rotary engine including a pair of end housings and a crankshaft rotatably supported in said end housings and an annular end cover received about said crankshaft normally covering an oil supplied cavity on the outboard side of one of said end housings, said one end housing having located underneath a drain-vent hole to which oil drains and through which air can be vented into the engine and also having located underneath a suction-vent hole through which oil can be supplied to the engine's lubrication system and also through which air may be vented into the engine, an oil tank secured to said engine in an underneath location, said oil tank having a drain-vent hole sealingly connected to the drain-vent hole in said one end housing, said oil tank also having a suction-vent hole sealingly connected to the suction-vent hole in said one end housing, suction passage means extending from said oil tank through said suction-vent holes into said engine, vent passage means also extending from said oil tank through said suction-vent holes into said engine, said end cover having a wall cooperating with said end housing on the outboard side to provide a quiet zone shielded from said oil supplied cavity elevated above said oil tank, an upwardly extending elongated vent passage in said one end housing connecting said vent passage means to said quiet zone at a low location, and another vent passage in said one end housing connecting said quiet zone at a high location to the engine's internal breathing system at a place away from any oil drainage.

2. A rotary engine including a pair of end housings and a crankshaft rotatably supported in said end housings and an annular end cover received about said crankshaft normally covering an oil supplied cavity in an annular projection on the outboard side of one of said end housings, said one end housing having located underneath a drain-vent hole to which oil drains and through which air can be vented into the engine and also having located underneath a suction-vent hole through which oil can be supplied to the engine's lubrication system and also through which air may be vented into the engine, an oil tank secured to said engine in an underneath location, said oil tank having a drain-vent hole sealingly connected to the drain-vent hole in said one end housing, said oil tank also having a suction-vent hole sealingly connected to the suction-vent hole in said one end housing, suction passage means extending from said oil tank through said suction-vent holes into said engine, said suction passage means and said oil tank around said oil tank suction-vent hole providing an annular vent passage about said suction passage means open to said oil tank, said end cover having an inwardly extending wall with a circumferentially extending face engaging the outboard side of said end housing and radially outwardly extending ends extending to said annular projection to provide a quiet zone shielded from said oil supplied cavity elevated above said oil tank, an upwardly extending elongated vent passage in said one end housing connecting said vent passage to said quiet zone at a low location, and another vent passage in said one end housing connecting said quiet zone at a high location and in a transverse direction to the engine's internal breathing system at a place away from any oil drainage.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 3,929,117

DATED : December 30, 1975

INVENTOR(S) : Raymond J. Green, Paul D. Stevenson

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

Column 2, line 45, "stationry" should read -- stationary --.
Column 6, line 63, after "drains" insert -- to drain --.

Signed and Sealed this

Fourteenth Day of September 1976

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks