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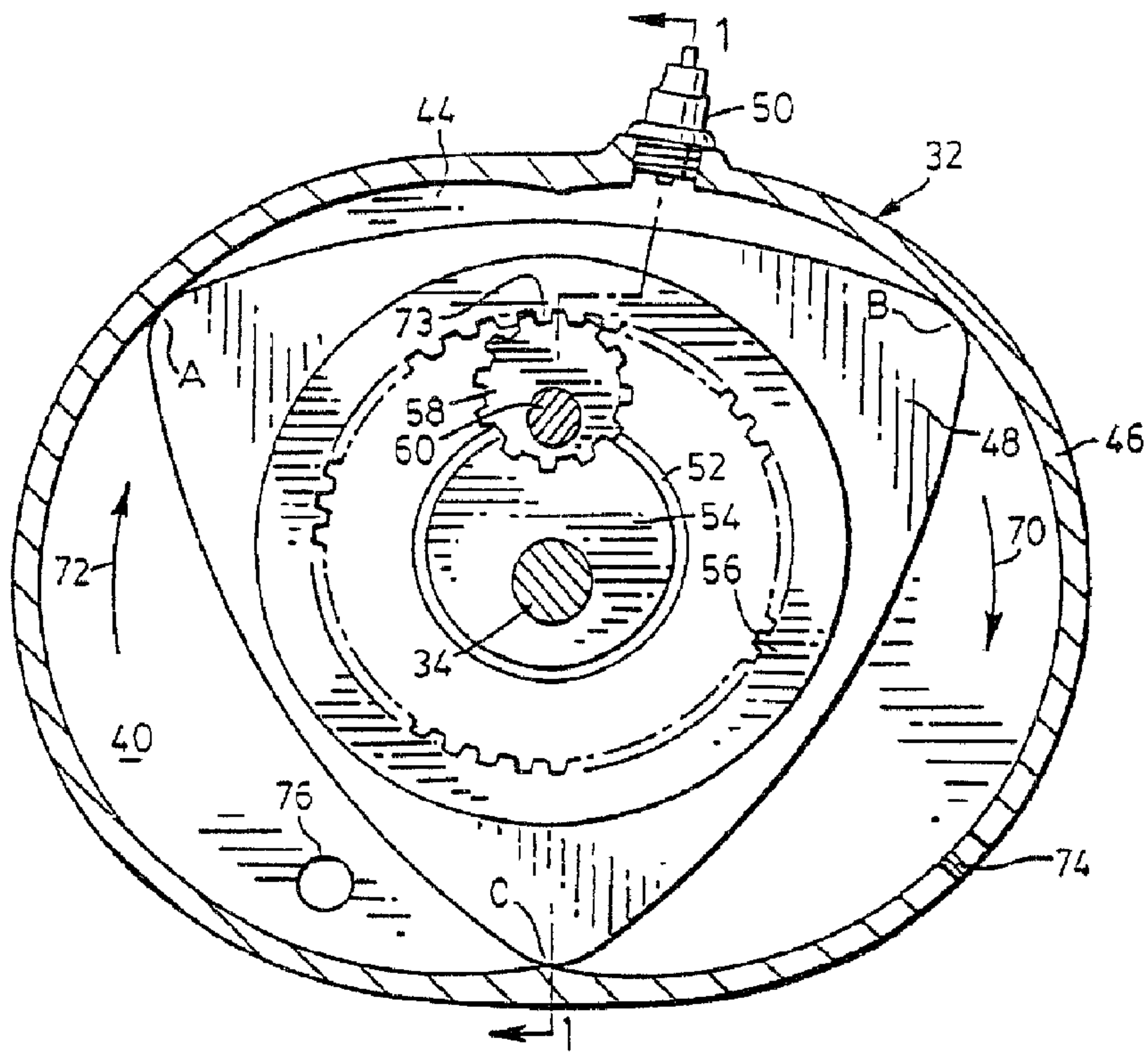
(54) Title: ROTARY ENGINE



(57) Abrégé/Abstract:

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(54) Title: ROTARY ENGINE

(57) Abstract

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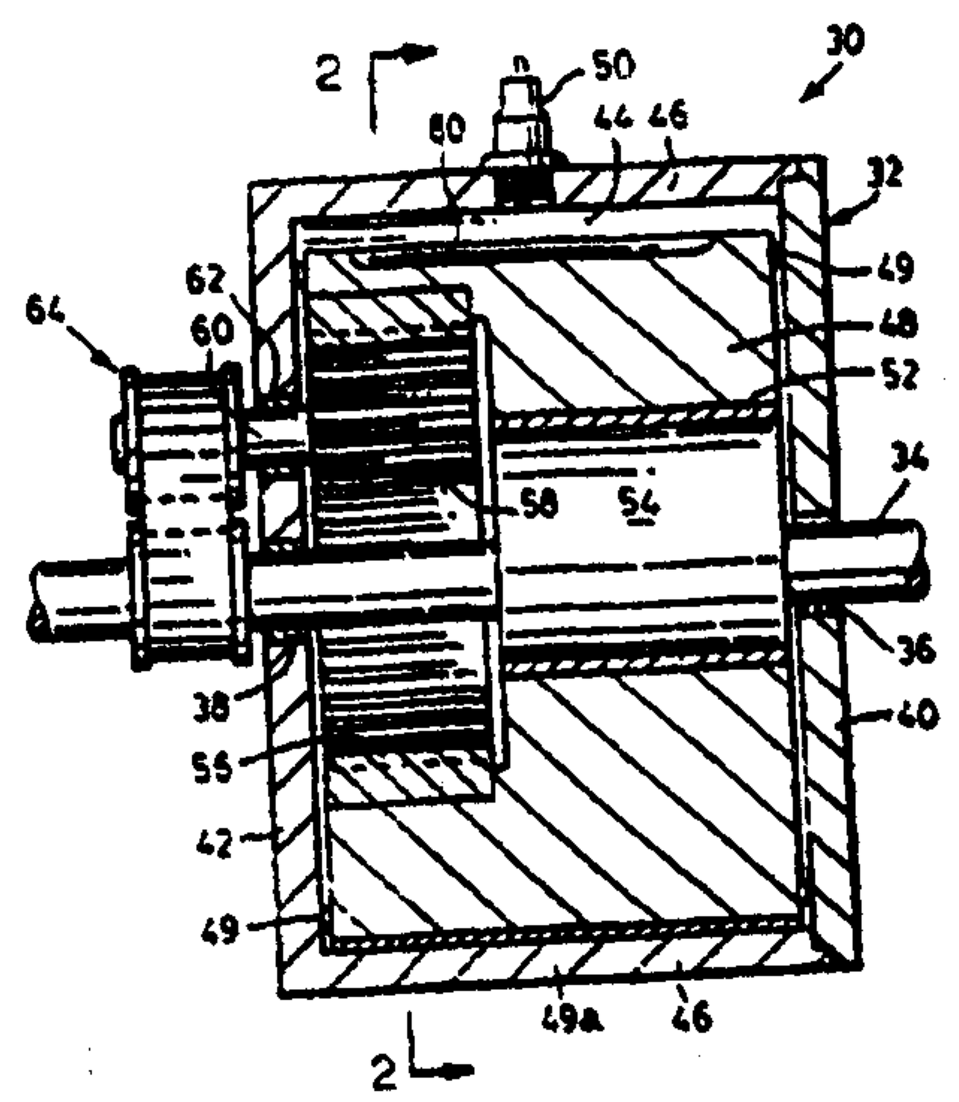

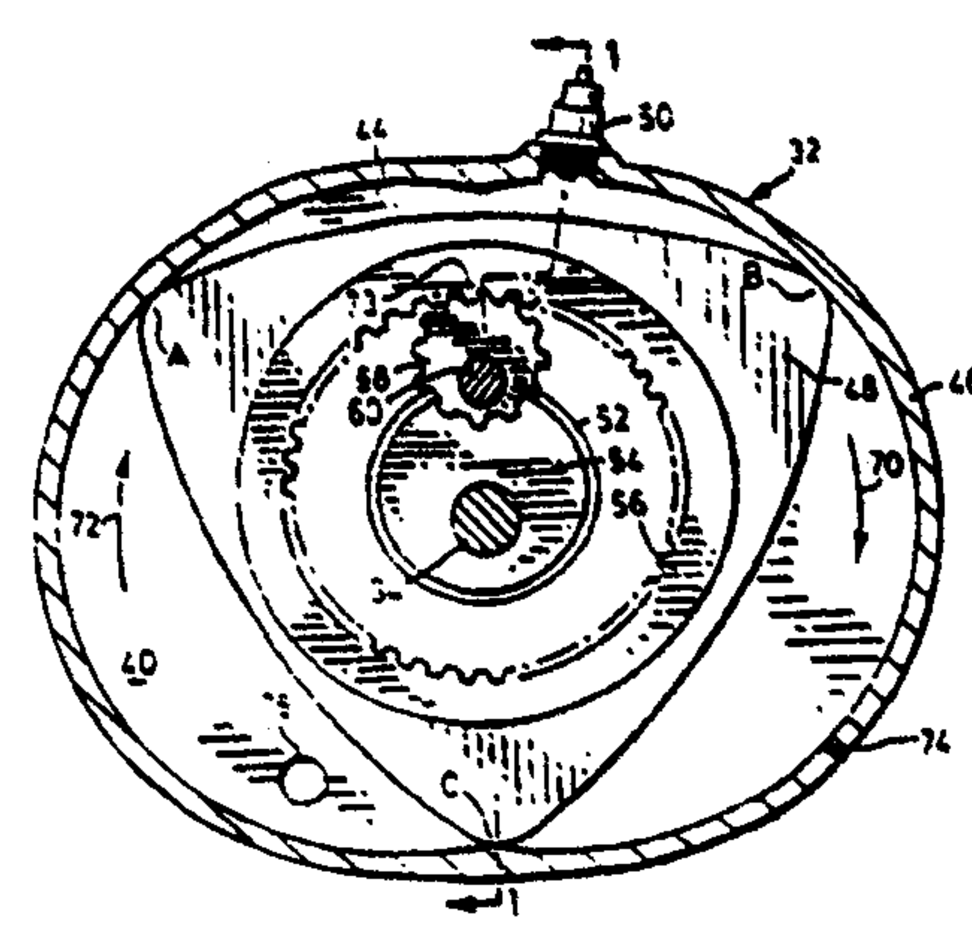

ROTARY ENGINE

TECHNICAL FIELD

This invention relates to rotary engines and, in particular, to a rotary engine having a rotor which rotates in a housing.

Rotary engines are an alternative to the more common piston engine and theoretically provide advantage in weight per unit of power output. Rotary engines can run on most combustible fuels, such as gasoline, diesel or hydrogen and can be used in land, sea or air vehicles.

This invention pertains to the type of rotary engine having a rotor which is turned in a housing and sweeps a volume of fuel through the stages of intake, combustion and exhaust. Examples of this type of rotary engine are found in U.S. Patents 4150926, 4389172, 4487561 and 5067883. The invention will be described with respect to a rotary engine having a rotor with three apexes, positioned at angles of 120 degrees to one another. The engine has gears to transmit power to a transmission or the like and to guide the rotor in a housing having a dual-lobed epitrochoidal shape. There are, however, applications of the invention in rotary engines having rotors with two or more apexes. The corresponding geometrical shape of the housing for a particular rotor can be determined in a manner well-known in the art.

BACKGROUND ART

There has generally been a problem in sealing the combustion chambers between the moving rotor and the stationary housing. The rotor and the housing must be sealed in two places. The first is along the apices of the rotor as it follows the epitrochoidal shape of a side wall of the housing, and the second is between the edges of the rotor and the front and back faces of the housing. Without proper sealing of the chambers, blow-by and poor compression will be present in the engine.

Prior art rotary engines have attempted to solve this problem by providing, for example, seals of different materials and uses, spring-loaded and fluid pressure-actuated construction. An example of an improved seal can be found in U.S. Patent 4137024 disclosing a spring-loaded seal.

While it is important to provide new solutions for a better seal, it is also imperative to provide a rotary engine which exhibits as little force as possible in the seals throughout its use. A common problem with prior art rotary engines is that, at the characteristically high engine speeds and forces, the gears transmitting the power and the bearings supporting rotation tend to wear, and this introduces lateral or rotational play between the rotor and the housing. A main cause of early wear in a rotary engine is that the rotor moves eccentrically in the housing. This causes unbalanced forces acting on the bearings holding the rotor which promotes rotor wobble and gear wear. Attempts to minimize the effects of the eccentric rotation have led to providing counterbalances along the drive-shaft of the engine. An example is shown in U.S. Patent 4132513.

The eccentricity of the rotor is normally determined by the gearing ratio between an internal ring gear centrally mounted on one side of the rotor and a central gear mounted on the drive-shaft extending coaxially through the housing. The ring gear and the rotor rotate eccentrically around the central gear. Particularly for a rotary engine with a three apex rotor, the gearing ratio between the ring gear and the central gear is conventionally 3:2. This will yield the proper rotation of the rotor so that its apexes follow the side wall of the epitrochoidal housing. The eccentricity of the rotor, fixed relative to the gear size, can be determined to be one quarter the diameter of the pinion gear. Therefore, the eccentricity of the rotor will increase for engines having a larger pinion gear and ring gear. It is desirable to be able to keep the eccentricity of the rotor at a minimum to reduce unbalanced forces even when using a large ring gear which has improved strength and wear characteristics.

There are rotary engines which have provided eccentric pinion gears to provide for eccentricity independent from the gear size. Examples are U.S. patents 374494 (Nestor) issued July 10, 1973 and 3875905 (Duquette) issued April 8, 1975. In the rotary engines of these references, all of the force of combustion is transmitted through the gears and thus wear on the gears is promoted which may yield unsatisfactory results.

DISCLOSURE OF INVENTION

It is among the objects of the invention to provide an improved rotary engine.

Accordingly, in one of its aspects, the invention provides a rotary engine comprising:

a housing having two opposing internal faces and a side wall joining said faces;

a driven shaft having an axis of rotation orthogonally extending substantially through at least one of said opposing internal faces, the driven shaft having a lobe portion eccentric to said axis and located in the housing;

a rotor rotatably mounted on said lobe portion and having an internal ring gear substantially co-axial with said lobe portion;

a pinion gear meshing with the ring gear and eccentrically fixed on a pinion shaft, the pinion gear having the same eccentricity as said lobe portion, the pinion shaft extending orthogonally through one of said opposing internal faces of the housing and being rotatably therein; and

drive means for transmitting torque between said pinion shaft and the driven shaft so that, as the rotor is turned, the rotor substantially follows said side wall of the housing.

An advantage of the invention is that the eccentricity of the rotor is not dependent on the gear size. This is because the pinion gear is offset from the axis of rotation of the rotor and rotates eccentrically with the rotor. Thus, the eccentricity of the rotor can be reduced, thereby reducing unbalanced forces in the engine and minimizing the weight of counterbalance requirements.

Another advantage of the invention is that the force on the meshing gear teeth during combustion is reduced for a given diameter pinion gear. This is a result of the eccentricity of the pinion gear which provides a greater distance or moment arm from the centre of the pinion shaft to the meshing gear during combustion that if the pinion gear were centred on the shaft. Thus, for a given torque output, the force on the meshing gear teeth is reduced.

Another advantage of the invention is that the force of combustion on the rotor is shared by the eccentric lobe and the pinion gear.

A further advantage of the invention is that a counter-balance may be placed inside the rotor due to the eccentric pinion gear construction. The engine can be completely balanced and is eminently suitable for ultra high speed operation. Larger engines can be installed in vehicles for mass transportation such as buses, street-cars, trains and naval or commercial ships.

DESCRIPTION OF DRAWINGS

The invention will be more fully understood with reference to the following drawings, in which:

Fig. 1 is a partially sectional side view of a rotary engine according to a preferred embodiment of the invention;

Fig. 2 is a schematic sectional view on line 2-2 of Fig. 1 showing a rotor of the rotary engine in a first position;

Fig. 3 is a view similar to Fig. 2 wherein the rotor has turned 30 degrees;

Fig. 4 is a view similar to Fig. 2 wherein the rotor has turned 60 degrees from the position shown in Fig. 2;

Fig. 5 is a view similar to Fig. 2 wherein the rotor has turned 90 degrees from the position shown in Fig. 2, and

Fig. 6 is a view similar to Fig. 1 showing two engines coupled back-to-back on a common shaft.

BEST MODE FOR CARRYING OUT THE INVENTION

Referring firstly to Fig. 1, a rotary engine 30 according to the invention is depicted. A sealed housing 32 covers and supports the working parts of the rotary engine 30. A driven shaft 34 extends orthogonally through the housing 32 and is supported by bearings 36, 38 in opposing internal faces 40, 42 of the housing 32. The driven shaft 34 would be coupled to a transmission or the like to drive a machine such as an automobile, motorcycle, or lawnmower, boat or airplane.

Various fuels could be used, but the most common would be a mixture of gasoline and air. The mixture is inspired by the engine (30) to enter a chamber 44 formed between a side wall 46 of the housing 32 and a rotor 48. The chamber 44 is sealed by side seals 49. An apex seal 49a is provided on each apex of the rotor 48 to complete the sealing of the chambers. At an appropriate time, the fuel is ignited by a spark plug 50. The combustion of the fuel causes the rotor 48 to rotate on bearing ring 52 about a lobe 54 which is fixed eccentrically to the driven shaft 34. As the rotor 48 rotates, a centrally mounted internal ring gear 56 (better shown in Fig. 2) meshes with and turns a pinion gear 58. The pinion gear 58 is eccentrically fixed on a pinion shaft 60 which extends orthogonally through the face 42 of the housing 32 and is supported in bearings 62. On the outside of the housing 32, the end of the pinion shaft 60 is coupled with the driven shaft 34 by a toothed belt drive 64 or a gear drive or other positive drive in a 1:1 ratio so that the pinion gear 58 will turn once for every turn of the eccentric lobe 54.

The force of combustion on the rotor 48 is supported along the width of the rotor 48 by the pinion gear 58 and the eccentric lobe 54. These, in turn, are supported by their respective shaft bearings 62, 36, 38 in the housing 32.

It should be noted that the eccentricities of the pinion gear and the lobe 54 are equal which means they are in the same direction and of the same magnitude. Therefore, as the pinion gear 58 is driven, its eccentric motion is matched by the eccentric motion of the lobe 54. This keeps the ring gear 56 meshed with the pinion gear 58. With the driven shaft 34 centred in the housing 32, the geometry of the gears when at a 1:3 ratio dictates that the eccentricity of the pinion gear 58 must be smaller than the radius of the pinion gear 58 less the radius of the driven shaft 34 in order for the pinion gear 58 to clear the driven shaft 34 as it rotates.

Reference is now made to Figs. 2-5 which will be used to explain the various positions of the rotor during the use of the rotary engine.

Fig. 2 shows the rotor 48 having three apexes A, B and C. As the rotor 48 turns, it is moved downwards and to the right by the eccentricity of the lobe 54 and pinion gear 48 and at the same time, the rotor 48 is being rotated by the pinion gear 58 so that the apexes A, B and C follow the side wall 46 which is of a dual-lobed epitrochoidal shape. The chamber 44 contains the compressed combustible fuel mixture (compression will be described later). The rotor is initially turned by a device such as a starter motor or a pull cord until, as the rotor 48 turns clockwise, the spark plug 50 ignites the mixture in chamber 44 causing an explosion which forces the rotor 48 to turn on the bearing ring 52 in a clockwise direction following arrows 70 and 72. It can be seen in Fig. 1 that the distance from the centre of the pinion shaft 60 to the point where the pinion gear 58 meshes with the ring gear 56 is at a maximum. This provides a larger moment arm and the force on the meshing teeth 73 is less for a given torque.

Fig. 3 shows the rotor 48 turned 30 degrees clockwise from the Fig. 2 position and the volume of chamber 44 has increased because of the geometry of the rotor 48 and the housing 32. It should be noted that the ratio of the pinion gear 58 to the ring gear 56 is 1:3 therefore, it can be seen that as the rotor 48 has turned 30 degrees, the pinion gear 58 has turned 90 degrees. The eccentric lobe 54, joined with a 1:1 ratio to the pinion gear 58, also turns 90 degrees. This keeps the pinion gear 58 synchronized with the ring gear 56 and moves the rotor 48 so that the apexes A, B and C continue to follow the side wall 46 of the housing 32. The pinion gear 58 and ring gear 56 will mesh at all positions of the rotor 48 because there is no relative movement between the centres of their rotation.

In Fig. 4, the rotor 48 has turned 60 degrees from the Fig. 2 position and the pinion 58 and lobe 54 have turned 180 degrees. At this point, the combusted mixture in chamber 44 is about to exhaust through exhaust port 74. The rotor then moves on to the Fig. 5 position where it has turned a total of 90 degrees from the Fig. 2 position and the pinion gear 58 and lobe 54 turned through 270 degrees. The spent fuel mixture in chamber 44 is exhausting through port 74.

Returning to Fig. 2, further exhausting of the combusted fuel can be seen, looking at the chamber between apexes B and C. It can be seen that the exhaust in the chamber is being swept by the rotor 48 through the exhaust port 74 by a reducing volume in the chamber. Further reduction of the volume between the apexes B and C is shown in Fig. 3. In Fig. 4, the volume of the chamber between apexes B and C is at a minimum and this is where the exhaust port 74 is closed to this chamber. Therefore, most of the spent fuel mixture has been exhausted through port 74.

Intake of the fuel into the chamber between apexes B and C begins when the volume of the chamber is at a minimum, as shown in Fig. 4. A fuel intake port 76 can be seen in dashed line and is about to be uncovered as the rotor 48 is turned. In Fig. 5, the intake port 76 is revealed and the increasing volume of the chamber aids in sucking in the fuel. In Fig. 2, this intake is shown in the chamber between apexes A and

C. The volume of the chamber continues to increase until, as illustrated in Fig. 3, the chamber volume is at a maximum and the intake port 76 is closed. From this point in, as the rotor is turned, the volume in the chamber will decrease and compress the fuel as shown in Figs. 4-5. Finally, the rotor is turned to a position as shown in Fig. 2, where the fuel is compressed fully in chamber 44. The exhaust port 74 and intake port 76 have been positioned for simplicity of description. By providing a spring-loaded divider (not shown) where the lobes of the epitrochoidal met at the bottom of the housing 32, minimum volumes of the chambers can be reduced so that the exhaust port is on the right of the divider and the intake port is on the left of the divider. This arrangement is well-known in the art.

Overall, the three apex rotor 48 creates three chambers, all of which go through the stages of fuel intake, compression, combustion, and exhaust as the rotor 48 is rotated through 360 degrees. When the rotor 48 makes one revolution, the pinion gear 58 rotates three times, thus driving the driven shaft 34 to make three revolutions. For each combustion, the driven shaft 34 is turned one revolution.

The size of the rotary engine can be determined from the maximum volume of the intake chamber. This is the volume in the chamber between apexes A and C shown in Fig. 3. At this point, the eccentricity of the rotor 48 and the lobe 54 positions the rotor 48 to the extreme right of the engine 30. This volume would be multiplied by three for the three chambers per revolution of the rotor, to give the capacity of the engine which dictates the horsepower.

The compression ratio is the ratio between the aforementioned maximum volume and the volume of the chamber 44 as drawn in Fig. 2. A typical maximum volume for a chamber would be in the range of approximately 30 cubic centimetres (1.8 cubic inches) to approximately 500 cubic centimetres (30 cubic inches). The volume will depend on the height of the side wall 46, the curve of the rotor 48, and the shape of the housing 32. An engine with a maximum volume of 50 cubic centimetres (3 cubic inches) has been found to operate adequately. Likewise, an engine with a maximum volume of 80 cubic centimetres (4.9 cubic inches) operates adequately. Compression ratios may vary as desired. An average compression ratio would be approximately 6:1, and a suitable range is from about 3:1 to about 12:1. The compression ratio and volumes can be altered by providing cavities formed in the sides of the rotor in a conventional manner, such as, cavity 80, shown in Fig. 1.

Fig. 6 illustrates the combining of two rotary engines, as previously described, joined together to drive a common driven shaft 100. Two oppositely eccentric lobes 102, 104 are mounted on the shaft 100. Rotors 106, 108 are mounted on the lobes 102, 104 respectively so that when an apex of rotor 108 is at bottom dead-centre, an apex of rotor 106 is at top dead-centre. This will provide alternate combustion on the two rotors 106, 108 and maximum torque on the driven shaft 100 will occur every one-half revolution of the driven shaft 100 instead of every one revolution. Pinion gears 110, 112 are mounted on a common pinion shaft 114 so that their eccentricities are opposite to one another. more engines can be added to the same shaft to provide more power. This and other embodiments will become apparent to a person skilled in the art, the scope of the invention being defined by the appended claims.

INDUSTRIAL APPLICABILITY

The engine is suitable for use in sea, land and air vehicles and can operate with most combustible fuels such as gasoline, diesel or hydrogen.

INDEX OF REFERENCE SIGNS

30	rotary engine
32	housing
34	driven shaft
36	bearings
38	bearings
40	face
42	face
44	chamber
46	side wall
48	rotor
50	spark plug
52	bearing ring
54	lobe
56	ring gear
58	pinion gear
60	pinion shaft
62	bearings
64	drive
70	arrow
72	arrow
74	exhaust port
76	fuel intake port
80	cavity
100	common drive shaft
102	lobe
104	lobe
106	rotor
108	rotor
110	pinion
112	pinion
114	pinion shaft

AMENDED CLAIMS

[received by the International Bureau on 6 September 1994 (06.09.94); original claims 1,5,7 and 11 amended; remaining claims unchanged (4 pages)]

1. In a rotary engine (30) of the type having a housing (32) including two opposing internal faces (40,42) and a side wall (46) joining said faces, a driven shaft (34) about an axis of rotation extending substantially orthogonally through at least one of said opposing internal faces (40,42), a lobe portion (54) mounted eccentrically about said axis on the driven shaft (34) and located in the housing (32), a rotor (48) rotatably mounted on said lobe portion (54) and having an internal ring gear (56) substantially coaxial with said lobe portion (54), the improvement comprising: a pinion gear (58) meshing with the ring gear (56) and having the same eccentricity as said lobe portion (54) and a drive (64) for transmitting torque between said pinion gear and the driven shaft so that as the rotor (48) is turned, the rotor (48) substantially follows said side wall (46) of the housing (32).

2. A rotary engine (30) as claimed in Claim 1 wherein the rotor (48) has three apexes (A, B, C) which follow said side wall (46) of the housing (32) as the rotor (48) is turned.

3. A rotary engine (30) as claimed in Claim 2 wherein the ratio of the pinion gear (58) to said ring gear (56) is 1:3.

4. A rotary engine (30) as claimed in Claim 2 wherein said side wall (46)is substantially epitrochoidal in shape.

5. A rotary engine (30) as claimed in Claim 1 wherein the drive means (64) operates on a 1.1 ratio between said pinion gear (58) and the driven shaft (34).

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6. A rotary engine (30) as claimed in Claim 5 wherein the drive (64) is a toothed belt, a gear train, or a chain drive system (64).

7. A rotary engine (30) as claimed in Claim 2 wherein the driven shaft (34) is spaced from the axis of the pinion gear (58) by at least a length equal to a radius of the pinion gear less a radius of the driven shaft (34).

8. A rotary engine (30) as claimed in Claim 1 wherein there are chambers (44) between the rotor (48) and the housing (32) which change in volume as the rotor (48) is turned.

9. A rotary engine (30) as claimed in Claim 8 wherein fuel intake of a combustible fuel into one of said chambers begins when said one of said chambers (44) is substantially at a minimum volume and continues until said one of said chambers (44) is substantially at a maximum volume.

10. A rotary engine (30) as claimed in Claim 8 wherein combustion of a combustible fuel in one of said chambers (44) occurs when said one of said chambers (44) is substantially at a minimum volume.

11. A rotary engine (30) as claimed in Claim 8 wherein combustion occurs in a chamber (44) when the distance from the axis of the pinion gear (58) to a meshing point of the pinion gear (58) and said ring gear (56) is substantially at a maximum.

12. A rotary engine (30) as claimed in Claim 8 wherein exhaust of a combusted combustible fuel from one of said chambers (44) occurs from when said one of said chambers (44) is substantially at a maximum volume to when said one of said chambers (44) is substantially at a minimum volume.

13. A rotary engine (30) as claimed in Claim 8 wherein a maximum volume in a chamber (44) is in the range of from about 30 cubic centimetres (1.8 cubic inches) to about 500 cubic centimetres (30 cubic inches).

14. A rotary engine (30) as claimed in Claim 13 wherein said maximum volume is about 50 cubic centimetres (3 cubic inches).

15. A rotary engine (30) as claimed in Claim 13 wherein said maximum volume is about 80 cubic centimetres (4.9 cubic inches).

16. A rotary engine (30) as claimed in Claim 8 wherein a ratio of maximum to minimum volume in a chamber (44) is in a range of from about 3:1 to about 12:1.

17. A rotary engine (30) as claimed in Claim 16 wherein said ratio is about 6:1.

18. A rotary engine (30) as claimed in Claim 16 wherein cavities (80) are cut in the rotor (48) to produce said maximum to minimum chamber (44) volume.

19. In a rotary engine (30) comprising a housing (32) defining a cavity of substantially dual-lobed epitrochoidal shape and a driven shaft

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(34) having an axis of rotation orthogonally extending through the centre of the housing (32), the improvement comprising:

a lobe portion (54) mounted eccentrically about said axis on the driven shaft (34) and located in the housing (32);

a rotor having three apexes (A,B,C) substantially at 120 degrees to one another, the rotor (48) rotatably mounted on said lobe portion (54) and having a ring gear (56) substantially coaxial with said lobe portion (54);

a pinion gear (58) meshing with the ring gear (56) and fixed eccentrically on a rotatable pinion shaft (60), the pinion shaft (60) offset from the driven shaft (34), said eccentricity of the pinion gear (58) substantially equal to said eccentricity of said lobe portion (54); and

drive means (64) coupled to said pinion shaft (60) and the driven shaft (34) for transmitting torque between the two, so that as the rotor (48) rotates, said apexes (A,B,C) of the rotor (48) trace said dual-lobed epitrochoidal shape of the housing (32).

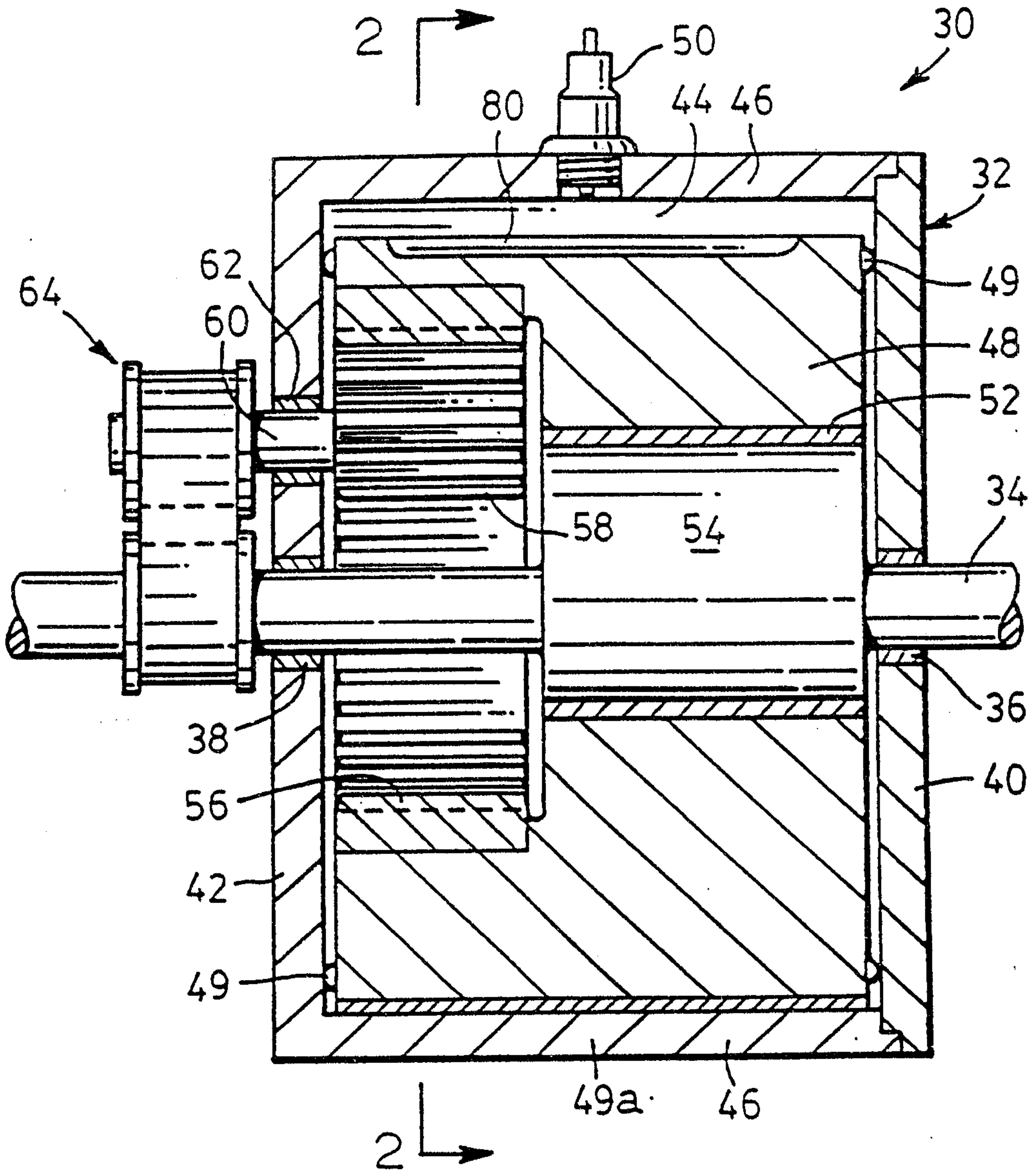

FIG.1

FIG.2

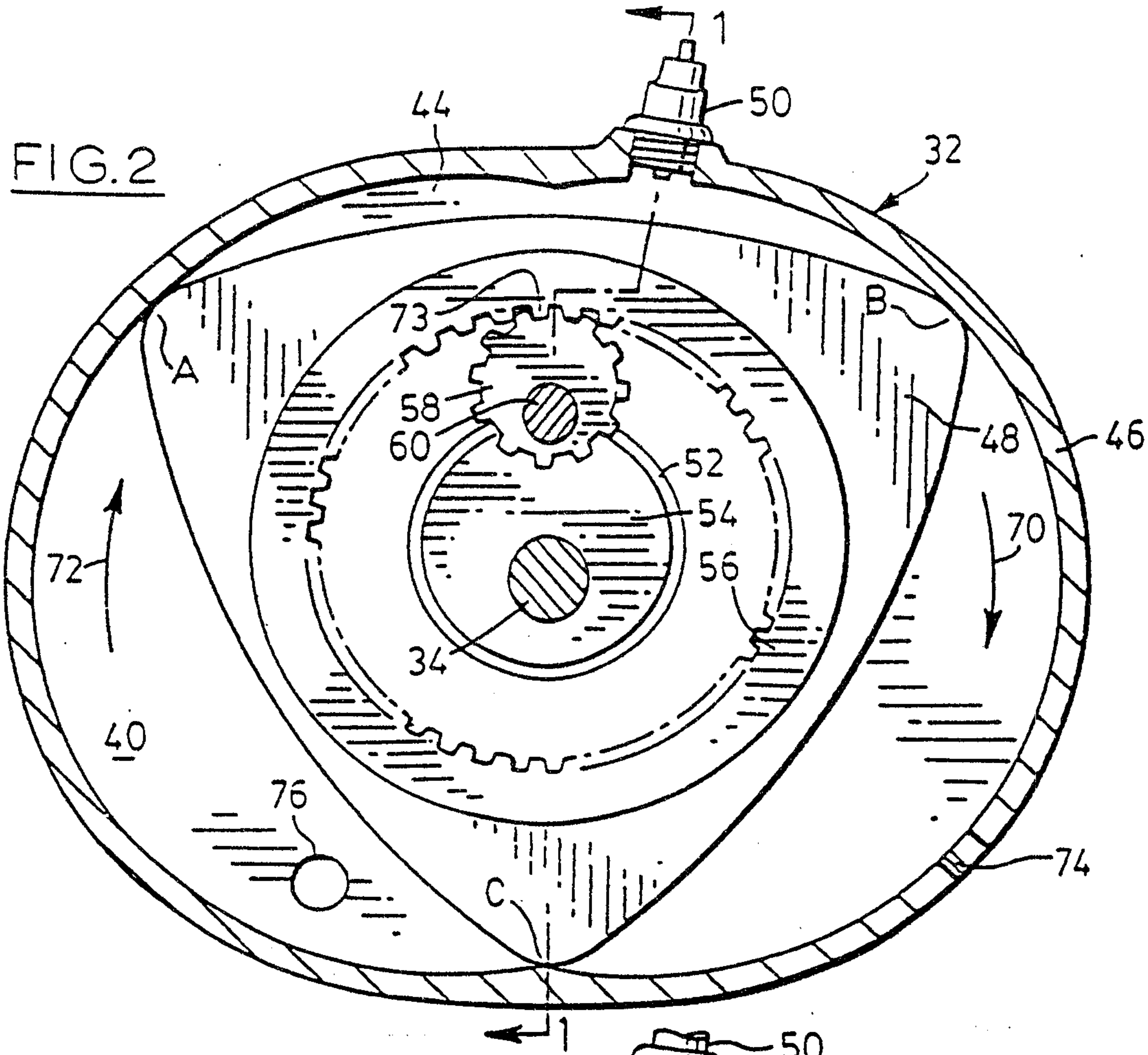
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FIG.3

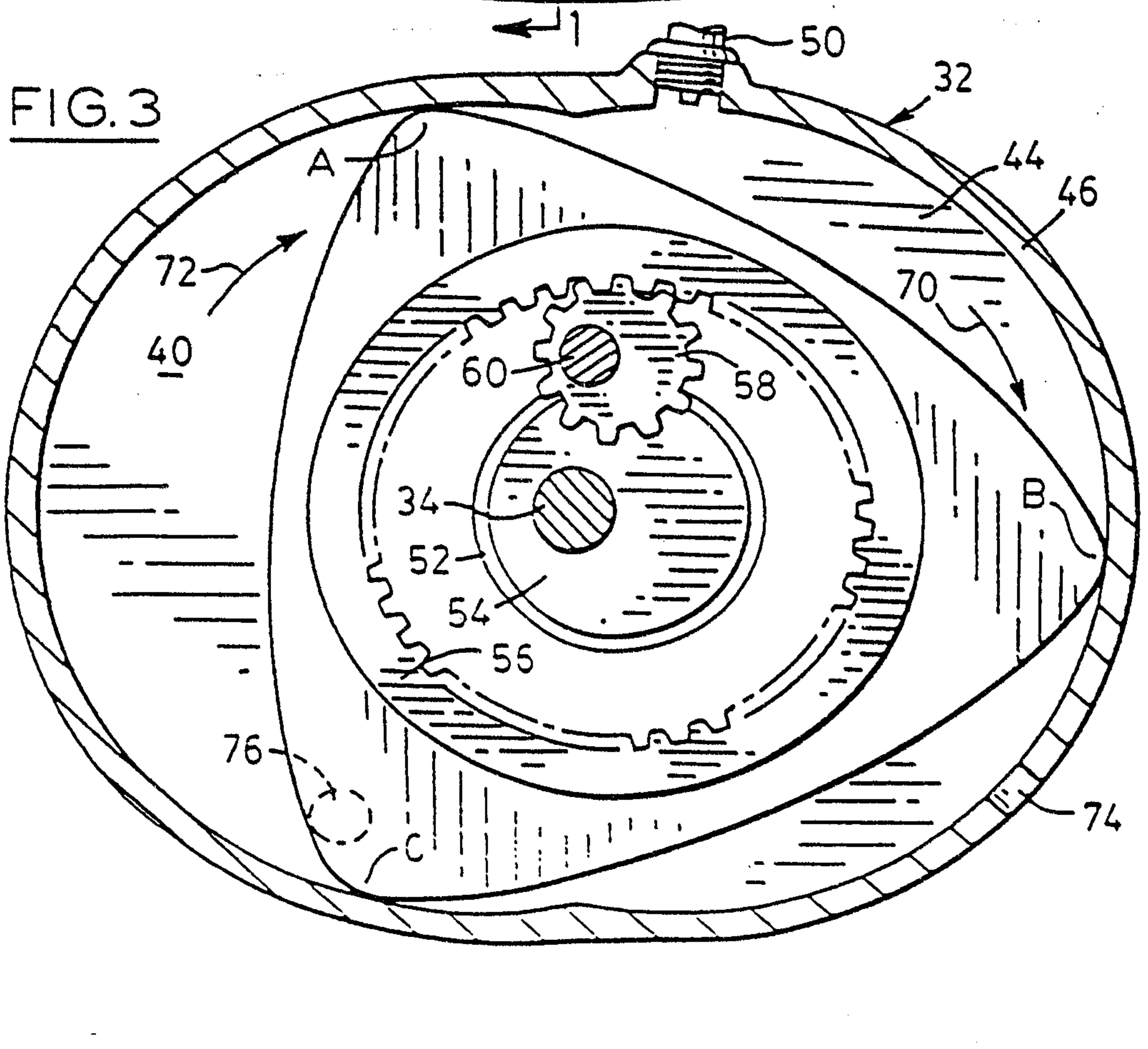
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FIG.4

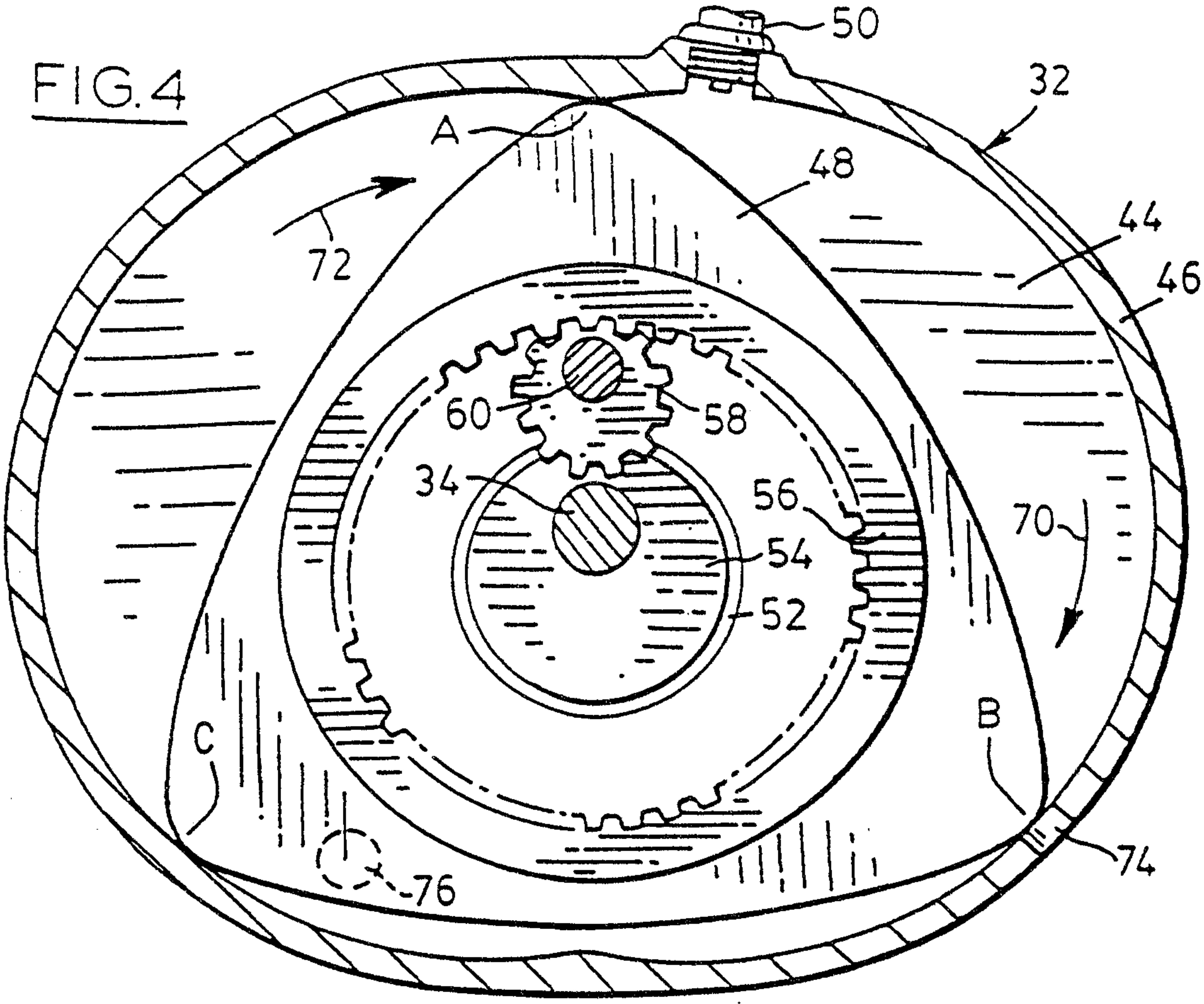
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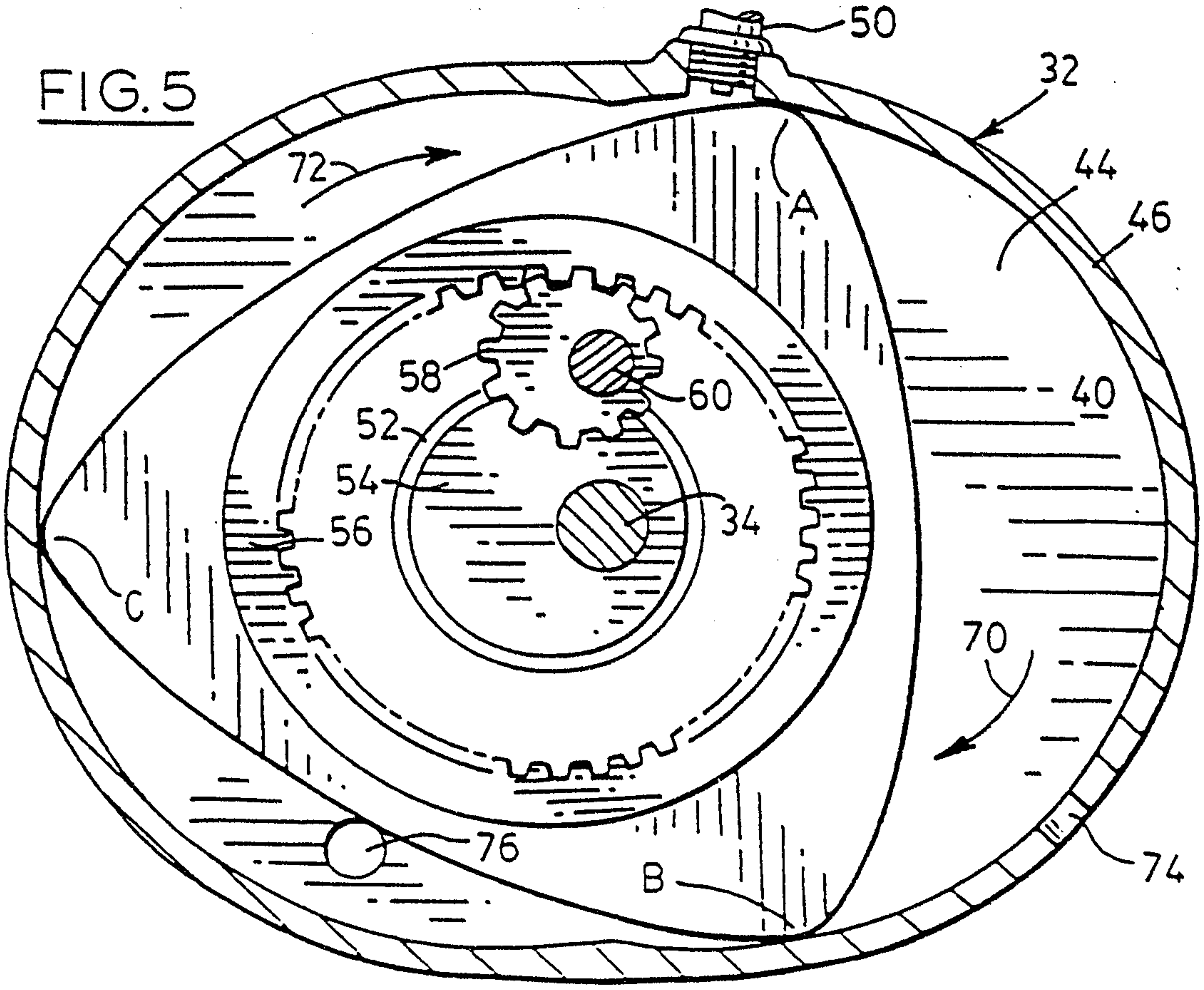
FIG.5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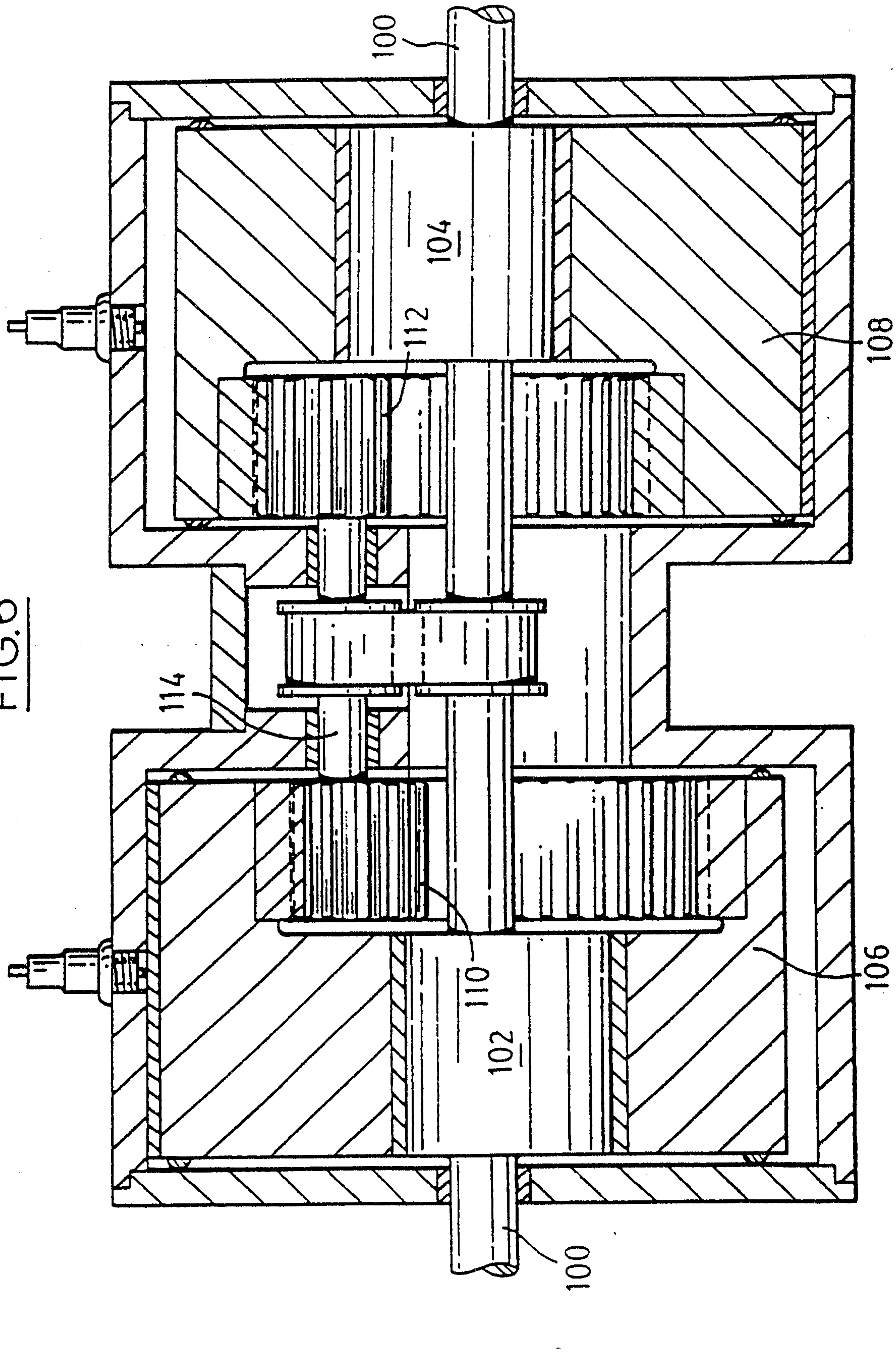
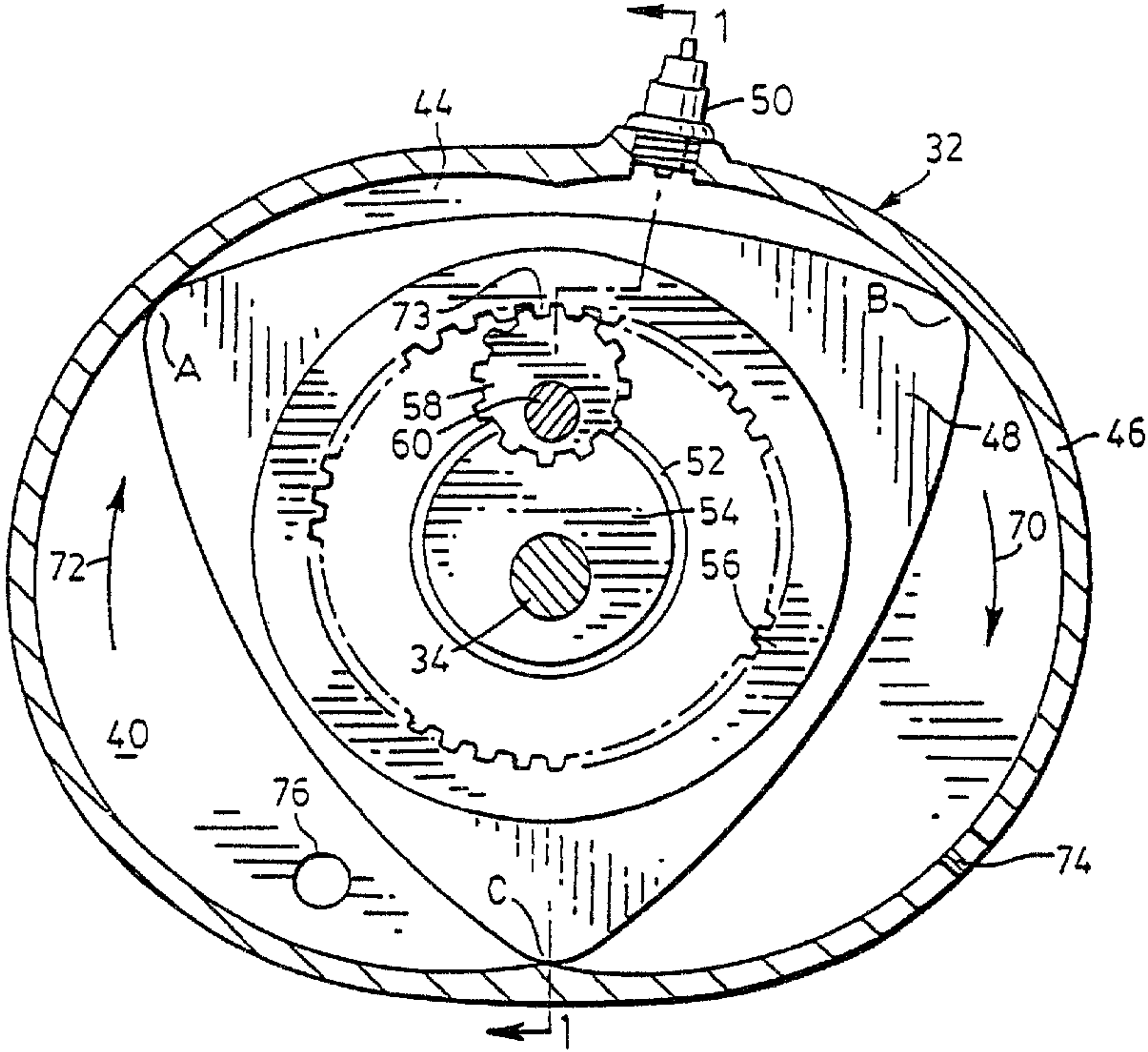


FIG.6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