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(71) Applicant: **Adiwinata, Sofyan**
Jalan Kebalen VII No. 3
Kebayoran Baru Jakarta (ID)

(72) Inventor: **Adiwinata, Sofyan**
Jalan Kebalen VII No. 3
Kebayoran Baru Jakarta (ID)

(74) Representative: **Troesch, Jacques J., Dr. sc. nat. et al**
Walchestrasse 19
CH-8035 Zürich (CH)

(54) Rotary internal combustion engine.

(57) A rotary internal combustion engine, including all types of vehicles and equipments or apparatus provided with such rotary engines, or machines which principally consist of 2,3 or 4 either radially curved or flat apex Rotor and a radially arcaded or curved epicyclic or 2 or 3 lobed epitrochoid Housing cavity, in which construction such rotary engine, the Rotor (21 of Fig.1), is integrated its rotations with the rotations of the main - crankshaft (24 of Fig.1), through the intermeshing gears train (37,38,4751,52,48 of Fig. 1) or through the planetary gears system or epicyclic gears train (324,348,360,359,362,361 of Fig. 5 & 6 and 362/I,362/II of Fig. 9 & 10) by which Rotor will be rotated or rotates in accordance to its specific basic speed ratio (such as 1 : 2 for bi-apex Rotor, 1 : 3 for tri-apex Rotor, etc.) so thereafter the Rotor will rotates to the effective clearance during all relative rotations and therefore is able to maintain such permanent distance between the cooperating shapes of the stationary outer components or the Housing and the rotating inner component or the Rotor, which distance will be used for inserting a proper sealing elements, which because of its geometrical nature of radially curved, it is therefore able to seal the working chambers precisely and eliminating any what so called corner seal leakages which is commonly occured in the conventional models, beside also able to avoid any possibility of direct contact between the Rotor apex portions and the inner Housing cavity wall so therefore such conditions will be able to maintain the minimum wearing rate between the moving parts as mentioned above, to the normal rate for engine durability. Said Rotor is also designed to have 6 lobed outer surfaces. Further the pitch diameter of the maincrankshaft is also made possible to be constructed larger than the conventional models of such similar engine and therefore will be able to avoid vibrations and carry more loads if required provided that both engine will used the same size of Rotor.

Such larger pitch diameter of the maincrankshaft is made possible because the pitch diameter of the internal ring gear as well as its pinion gear is made also larger than the conventional design as caused by using larger gearing ratio of 3 : 2 instead of 2 : 1 for bi apex Rotor and 4 : 3 instead of 3 : 2 for the 3 apex Rotor type.

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Description

ROTARY INTERNAL COMBUSTION ENGINE

THIS INVENTION relates broadly to the art of ROTARY MECHANISM and more particularly relates to the art of ROTARY INTERNAL COMBUSTION ENGINE, including all types of vehicles and equipments or apparatus provided with Rotary Internal Combustion Engines, and or Rotary Equipments/ Machines such as Rotary Compressors, Rotary Pumps, Rotary Cutting Tools, or lathes as well as Rotary System for Aircraft Engines, or any future flying crafts, using any kind of fuels suitable for such Rotary Internal Combustion Engines, either for land, sea or air transportations, and for any other special purposes as broad as possible, which hereinafter for the purpose of simplicity will be referred to as ROTARY ENGINE.

BACKGROUND OF THE INVENTION:

Rotary engines of the above mentioned type is comprises of an outer component having axially spaced end walls and a peripheral curved or parallel to the axis and an inner component having axially spaced end surfaces and a peripheral curved or parallel to the axis, which components hereafter for simplicity will be -referred to as the Housing and the Rotor, in which Housing defines a cavity in the shape of epicyclic for 2 apex Rotor or in the shape of 2 lobed epitrochoidal cavity Housing for the 3 apex Rotor.

Normally in such a Rotary engine, being eccentrically mounted on the maincrankshaft, an internal ring gear is fixed or secured within one side of the Rotor and intermeshed to a Pinion gear having a hollow shaft for free wheeling within the said maincrankshaft. Particularly for a rotary engine with 3 apex Rotor the gearing ratio of the internal ring gear : Pinion gear is fixed 3 : 2 for which thereafter the Pinion has to be fixed or secured to Housing frame. Such gearing ratio as mentioned above therefore will limit the diameter size of the maincrankshaft due to the given eccentricity of such design.

Such fixing the Pinion as mentioned above to the Housing frame kinematically will cause the power transmit dependent on the strength of the cavity wall -against the strong pressures of the Rotor which receive the powerfull impact -as caused by the expanding gas es soon after every ignition/combustion, particularly during extreme conditions when the engine is in operations.

Sooner or later such conditions will cause an excessively heavy wear along the contact lines between the cavity wall and the Rotor, which in the end will of course shorten the life or durability of the said engines.

Such Rotor having axially spaced end surfaces and a peripheral wall parallel to the axis which hereafter for the purpose of simplicity will be referred to as the Rotor with flat outer surface or flat Rotor, will cause what so called "Corner seal leakage" which is considered as one of the most serious problem to be solved due to its geometrical conditions.

By such limited size of the maincrankshaft, fixing the Pinion gear to the Housing frame, and corner sealing, the whole performance of this typical rotary engine has been characterized by widely known, relatively low efficiency -high fuel consumption, high emmissions, and excessive wearing etc.

SUMMARY OF THE INVENTION :

The object of the present inventions are to provide new system for eliminating all said above low performances by such using larger Pinion gear, to allow larger diameter size of maincrankshaft, rotating the said Pinion gear to allow direct power transmit to the maincranksfat and therefore avoiding the excessive wear along the contact lines between the Rotor and the cavity wall and using the radially curved apex Rotor portions as well as radially arcaded Housing cavity wall, between which will be inserted suitable sealing elements which able to eliminate the corner sealing problems as it may available in the conventional models.

Those mentioned above objects are achieved by instead of installing intermeshing gears as described in our previous applications (European Patent application No. 87.201780.1 and U.S. Patent application Serial No. 098 189) a planetary gears system or epicyclic gears train will be installed between the Rotor and the maincrankshaft to secure and fix the speed ratio of 1 : 3 or 1 : 2 as required in order to maintain the permanent and stable or constant clearance between the Rotor and the Housing cavity wall during all relative rotations. Such permanent, stable or constant clearance as mentioned above will avoid any direct contact of the Rotor to the Housing cavity wall particularly during an extreme conditions when the engine is in operations.

In such preferred embodiment, the arms of the planetary gear system or epi cyclic gears train will be constructed integral to the Pinion gear so therefore the planetary gears system is able to control the speed ratio of the said above Rotor and the maincrankshaft to 1 : 2 for 2 apex Rotor with an epicyclic Housing cavity and 1 : 3 for 3 apex Rotor with 2 lobed epitrochoid Housing cavity.

Unlikely with the conventional design, which the Pinion gear is fixed and secured to the Housing frame and therefore the Pinion will always stay at its stationary position, in this invention the Pinion will rotate or rotated according to intercorelation speed among the gears, and therefore will be able to prevent any possibilities that a strong dynamic force during any extreme conditions -may cause the Rotor to press the cavity wall in order to transmit the power -to the maincrankshaft of the engine, which of course will cause the wearing. The said above Pinion rotation are fixed to a fractional figure of 1/4 for 2 apex Rotor and 1/9 for 3 apex Rotor, which means that the said Pinion will rotate or rotated up to 90° for every 360° maincrankshaft rotation of the 2 apex Rotor engine and up to 40° for every 360° maincrankshaft rotation of the 3 apex Rotor engine,

by which rotation thereafter the Rotor will obtain its proper speed. Based on the said above constructions therefore it is now made possible to use larger internal ring gear which will be fixed or secured to one side of the Rotor. Such ring gear as mentioned above for the 2 apex Rotor will be constructed to a gearing ratio of 3 : 2 with its intermeshing Pinion gear, and for the 3 apex Rotor will be constructed to a gearing ratio of 4 : 3 with its intermeshing Pinion gear, which based on said above gearing ratio thereafter it is possible to use a larger size of maincrankshaft diameter for better and stronger performances. Based on the above mentioned constructions, it is therefore made possible to -use when necessary such i.e. for internal combustion engines, a radially curved apex Rotor portion which shape extends continuously from one to adjacent apex and which curve shape become minimum in the middle of said 2 adjacent apex Such radially curved apex Rotor shape is not necessary if such construction is used for compressors, pumps, cutting tools, etc.

In the case of internal combustion engines, within the outer surface of the said radial curved of the 3 apex Rotor will be constructed a channel between each of the 2 adjacent curved apex in order to obtain the proper compression ratio as it may required by the manufacturer, while within each radially curved apex portion of the Rotor will be provided with sufficient grooves for suitable rings or sealing elements installation seats i.e. such as beveled or normal grooves. If so desired such channels in the case of 3 apex Rotor engine is not necessary for the 2 apex Rotor engine's construction, because for the same purpose, the -curve of the 2 apex Rotor outer surface can be adjusted to as it may required for suitable compression ratio.

It is further object of the invention that particularly for the 2 apex Rotor engines, will be provided with an inlet and exhaust valves driven by one or more cam shaft/s having its speed ratio of 1 : 4 against the maincrankshaft rotations. Accordingly, because such an effective clearance between the cooperating -shapes of the radially curved apex Rotor and the radially arcaded Housing cavity wall, is now made possible by the invention, and maintain constantly permanent during all relative rotations of the Rotor, therefore the said sealing element will function properly and prevent any leakage of the compression from one into another working chambers dependent on its own spring power which therefore could maintain the permissible normal wearing rate for durability of such engines. In connection with the said above matter, the invention contemplates the chromeplated inner radially arcaded Housing cavity wall as well as for the sealing rings, for the purpose to obtain the smooth and hard chromed surfaces which has a good affinity for lubricating oil and reduce the sealing ring wearing rate significantly.

Particularly for the 3 apex Rotor, the present invention has a further object to provide that either curved or flat Rotor instead of construct it to have 3 apex with 3 lobed outer surfaces, it is now constructed to have still 3 apex but with 6 lobed of outer surfaces, which construction will enable the said 3 apex Rotor to fully wipe out completely the remaining volume of compressed fluid or gases into the outlet passage within the Housing cavity which thereafter the same outer surfaces will receive a new volume of fluid or gases from the inlet passage adjacent to the mentioned above outlet passage, to be brought forward into the suction chamber and compression chamber respectively.

When the said above construction is applied to internal combustion engines, the invention contemplates that the same channel as previously described will be constructed between each 2 adjacent apex for the purpose of adjusting the compression ratio as it may required by manufacturer, which channel of course will still cause the remaining burned gases brought forward and mixed it further with the new inserted air-fuel through adjacent inlet passage.

It is a further object of the invention that for both rotary engines using either 2 or 3 apex Rotor, a planetary gears system or epicyclic gears train will be installed between the Rotor and its maincrankshaft.

The said planetary gears system or epicyclic gears train are normally consisted of 3 different gears such as the sun, the planet and the static outer ring gear. The sun gear is the gear in the centre part of the system, while the planet is the intermeshed gear between the static ring gear and the said sun gear, and rotates to the opposite direction with the maincrankshaft and therefore enable the arm of the planet gears to rotate in the same direction with the maincrankshaft. In this specific constructions, the invention contemplates that the arm of the - planet gears will be constructed integral with the Pinion gear which is intermeshed to the internal ring gear fixed within one side of the Rotor, while the sun gear will be fixed or secured to the maincrankshaft i.e. by such involute spline gear. By said above mentioned constructions therefore, the maincrankshaft rotations is now integrated to the Rotor's rotations and the gearing ratio is fixed to the proper required gearing ratio as it may necessary to reach the speed ratio as previously mentioned such as 1 : 2 for 2 apex Rotor and 1 : 3 for 3 apex Rotor. For the 2 apex Rotor having internal ring gear and its pinion based on gearing ratio of 3 : 2, the suitable planetary gears system or epicyclic gears train will be constructed so as the sun, the planet and the static outer ring gear will be fixed according to the gearing ratio of 1 : 1 : 3.

By such construction therefore the arm of the planet gears will be rotated or rotates to 90° per every 360° revolution of the maincrankshaft.

For the 3 apex Rotor having internal ring gear and its pinion based on gearing ratio of 4 : 3, the suitable planetary gears system or epicyclic gears train will be constructed so as the sun, the planet and the static outer ring gear will be fixed according to the gearing ratio of 1 : 1 : 8, so therefore the arm of the planet gears will be rotated or rotates to 40° per 360° maincrankshaft rotation. But because by gearing ratio of 1 : 8 between the sun and the static outer ring gear is not practical if constructed, therefore the invention contemplates that the planet

gear as it may required instead of constructing it based on gearing ratio of 1 : 1 with the sun gear or 1 : 8 with the static outer ring gear, in this matter will be constructed in "cluster gear assembly" consisted of 2 integrated smaller and larger gears, which the smaller is intermeshed to the ring gear based on ratio of 1 : 4, and the larger intermeshed to sun gear to the ratio of 1 : 2.

By such construction therefore, the arm of the planet gears will be rotated or rotates to 40° per each 360° revolution of the maincrankshaft. Kinematically only one intermeshing gear is required as the planet gear, but by using three gears, there will be more balance available and the loads can be equally divided among the gears and therefore will make possible the - utilization of smaller or thinner gears used for the system.

Therefore, the planetary gears system or epicyclic gears train as mentioned above has more advantages compared to the intermeshing gears, particularly such as stable rotations, centering accuracy, simple constructions, etc.

It is further object of the invention to provide that particularly for the radially curved apex Rotor with radially arcaded Housing cavity, the Housing cavity construction will be made in 2 or more parts either crossing or parallel to the axis shaft dependent to the variation as it may necessary provided with proper gasket or rubber or any other suitable sealing as to prevent any possibilities of compression leakage, cooling water leakage as well as any lubricating oil leakage from one into another working chambers.

In connection with the Housing cavity constructions either for the radially curved apex portion or flat surface Rotor, the invention contemplates that - in order to obtain the correct and precision shape as to the same of the outer envelope of the Rotor based on speed ration of 1 : 3 to the maincrankshaft for the 3 apex Rotor, or speed ratio 1 : 2 to the maincrankshaft for the 2 -apex Rotor, including the permissible or allowed clearance as will be determined by the manufacturer, therefore, a special cutting tool which is constructed based on the same principles of the engine but provided with accurate -size of cutting blade fixed or secured to the said above tools, will be used to cut and form the inner Housing cavity precisely.

Such cutting tools should be constructed also based on the same eccentricity of the engine.

Similar cutting tools special for 3 apex Rotor with 6 lobed outer surfaces, either of radially curved or flat type, is also made possible by using the same principles, but unlikely the cutting tools for the Housing cavity which cut - while it is rotating to the property speed ratio, the cutting tools for this typical Rotor is constructed stationary.

For the preferred embodiment, the invention has further particular objects to provide the engines with the same gearing principles such as the gears for internal ring gear, the pinion, the intermeshing gears train as well as the planetary gears system or epicyclic gears train, but to be based on different gearing ratio, which will be determined or as resulted from the computation of the formula described in our previously submitted applications (European Patent applications No. 87.201780.1 and U.S. Patent application Serial No. 098 189) as follows:

$$\frac{\text{I.I.G.P.}}{\text{I.I.G.}} - \frac{a}{b} = p$$

in which:

I.I.G.P. refers to the pitch diameter of the internal involute gear pinion.

I.I.G. refers to the pitch diameter of the internal involute gear.

a/b designates the additional rotation of the internal involute gear on each rotation of the maincrankshaft, and

p designates the basic ratio of the specific type of rotary engine, being 1/2 for the rotary engine using 2 apex Rotor and epicyclic Housing cavity, and 2/3 for the rotary engine using 3 apex Rotor and 2 lobed - epitrochoid Housing cavity.

In connection with the above mentioned formula, the invention contemplates that the gearing ratio of the intermeshing gears train can be determined based on computations as follows:

a/b = I.I.G.P./I.I.G x c/d x e/f

in which c/d and e/f designate the gearing ratio of the intermeshing gears, and in case it is required more gears in order to obtain the right ratio, therefore - such computation can be extended to :

a/b = I.I.G.P./I.I.G x c/d x e/f x g/h.

Further objects and features of the invention will be apparent from the following descriptions of the preferred embodiment with reference to the drawings attached to this applications, including the Kinematics of the invention, etc.

DESCRIPTION OF THE DRAWINGS :

Figure 1 is a longitudinal section view of the rotary engine having radially curved 2 apex Rotor, and radially arcaded Housing cavity and intermeshing gears in between.

Figure 2 is a cross sectional view, partly taken on the line I-I and partly taken on the line II-II of the Figure 1.

Figure 3 are details motion of the 2 apex Rotor with epicyclic Housing.

Figure 4 is showing the 2 units of 2 apex Rotor combined in one engine.

Figure 5 & 6 are the planetary gears system applied to rotary engine having 2 curved apex Rotor and curved epicyclic Housing cavity.

Figure 7 is the longitudinal section view of a rotary compressor based on the invention principles, having planetary gears system applied for 2 flat apex Rotor and epicyclic Housing cavity, specially designed for car air conditioning system.

Figure 8 is the longitudinal section view of the special cutting tools to shape the Housing cavity.

Figure 9 & 10 are the planetary gears system

applied to rotary engine having 3 curved apex Rotor and curved 2 lobed epitrochoidal Housing cavity.

Figure 11 & 12 is cross sectional view of the rotary engine having 3 apex Rotor with 6 lobed outer surfaces and 2 lobed epitrochoid Housing cavity. The rotations of the apex portion is shown in Figure 11 based on the speed ratio of 1 : 3 to the maincrankshaft.

Figure 13 & 14 are the perspective view of the radially curved 3 apex Rotor provided with intermeshing gears system based on the principles of the invention, where in the Figure 13 is shown the exact positions of the curved apex portion of the Rotor during all relative rotation based on the speed ratio of 1 : 3 to the maincrankshaft.

Figure 15 is the perspective view of the whole engine unit and partly is shown in silhouetted broken away in which can be seen the radially curved 3 apex Rotors (2 units) and its Housing cavity based on the principles of the inventtion and provided with intermeshing gears system.

Figure 16 a,b,c & d are the drawings of the relative motions of the related parts in accordance with the Kinematic description of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT :

Referring to Figure 1 & 2, a rotary internal combustion engine according to this invention is provided with 2 units Rotor of the radially curved 2 apex 21 having curved Housing cavity 20 which rotors will be mounted to each of the eccentric hubshaft 23 made and constructed integral with the maincrankshaft 24, to have free wheeling by means of metal bearings between the rotor and the eccentric hubshaft 22 and between the maincrankshaft and the Housing frame 25.

The Rotor will be provided with side seal elements 27 which is connected with the apex seal elements 28 and lubricating oil scraper rings 26 & 29.

The curved Housing cavity is provided with inlet and outlet passages 30 which is controlled by means of valves 31 supported by coil springs 32 and which valves will be driven by means of camshaft 36 and rocker arms 33 and connecting rods 34.

The engine is also provided with ignitions by means of spark plugs 35 which is fixed or secured to the Hosuing frame 20 and which Housing frame has a supporting main body which is also to function as the lub-oil tank 39.

For the cooling system, the Housing frame will also be provided with cooling water passages 40 as conventionally constructed.

Within one side of the Rotor 21 will be fixed or secured an internal ring gear 37 which will be intermeshed to a pinion gear 38 to be based on gearing ratio of 3 : 2, and made or constructed in an integral cluster gears assembly with gear 47 having a hollow shaft for free wheeling around the maincrankshaft 24 by means of roller bearings 41.

The gear 47 is intermeshed with a gear 51 which is made or constructed in another cluster gears assembly with the gear 52 having a separate shaft 42. The gearing ratio between gear 47 and 51 is fixed at 2 : 1.

The gear 52 is intermeshed to a final pinion gear 48 which is fixed or secured to the maincrankshaft 24 by means of involute spline and strengthen by means of special locknut 49, and the gears 52 and 48 is fixed on gearing ratio 2 : 1.

The cluster gears assembly shaft 42 will be provided with bearing 43 which end of the shaft will be mounted to the Housing frame 20 and gear cover 50. Both ends of the maincrankshaft 24 will be mounted with ball bearings 44 and lub-oil seal 46 and seal cover 45 to prevent any lub oil leakage out of engine.

As shown in the Figure 3 the detailed motion of the Rotor 21, within the Housing cavity 20 is precisely drawn based on the speed ratio of 1 : 2 between the Rotor and the maincrankshaft 24.

The Housing cavity of an epicyclic form 20, and the permanent or constant clearance between the Rotor apex 21 and the Housing cavity 20 is therefore made possible by such constructions.

Figure 4, is showing the exact position of each Rotor as drawn in the Figure 1 & 2, at the same time and at the eccentric hubshaft distance of 180° between each other.

In this particular design the front Rotor 21 with apex sealing element 28 is mounted to the eccentric hubshaft 23 through bearings of 22 with the maincrankshaft of 24 driving at speed ratio of 1 : 2.

Because the rear eccentric hubshaft is positioned at a distance of 180° to the front eccentric hubshaft, therefore for balanced rotations and ignitions the Housing cavity of the rear part will be constructed higher than the front part due to the given eccentricity.

Such condition will cause that the inlet and outlet passages of the front part 30/I relatively will be higher than the inlet and outlet passages of the rear part 30/II, while the rear Housing cavity 20/II is relatively higher than the front Housing cavity 20/I.

Figure 5 & 6 are showing the planetary gears system or epicyclic gears train used for the same radially curved 2 apex Rotor 21 with radially arcaded Housing cavity 20.

In this construction, the sun gear 348 which is fixed or secured to the maincrankshaft 324, is intermeshed to 3 units of planet gears 362 which are mounted to the armshaft 361 for free wheeling, based on gearing ratio of 1 : 1.

The 3 units of planet gears 362 are also intermeshed to the outer ring gear of 359 based on gearing ratio of 1 : 3.

So therefore because of the superposition of the planet gears, the reduction of the arm 360 speed ratio then will be 1 : (3/1 + 1) = 1 : 4 or equal to 90° per each 360° revolution of the maincrankshaft. And by gearing ratio of 2 : 3 between the pinion gear 38 and internal ring gear 37, the Rotor 21 will be rotated or rotates up to (1 - 2/3) x 360° = 120°. As the arm is integrated to the pinion therefore by gearing ratio of 2 : 3 the internal ring gear will be rotated or rotates to 2/3 x 90° = 60° as additional rotation per each maincrankshaft 360° By adding the additional rota-

tion of 60° to its own rotation of 120° therefore the Rotor 21 will have totally 120° + 60° = 180° per each 360° maincrankshaft rotation, which is exactly according to the speed ratio of 1 : 2 as required by such 2 apex Rotor and epicyclic Housing cavity.

Figure 7 is a rotary compressor based on the invention principles and designed for car air conditioning system to the actual size of 1 : 1 to show how small and effective is the invention for such particular purpose. Such compressor is constructed to have 2 apex Rotor 421 with flat outer surfaces provided with proper sealing elements 427, within which the same material will be constructed an integral internal ring gear 437 and intermeshed to the pinion gear 438, based on gearing ratio of 2 : 3.

Such Rotor 421 will be mounted to the eccentric hubshaft made in one integrated with the maincrankshaft 424, for free wheeling through roller bearing installed in between, 422.

The pinion gear 438 is made integral with the arm of the planet gears 460 which is constructed to hold the armshaft 461 where the planet gears 462 will free wheeling around.

The sun gear is fixed or secured to the maincrankshaft by means of involute spline and intermeshed to the 3 unit of planet gears based on gearing ratio of 1 : 1. The 3 units of planet gears are also intermeshed to the outer ring gear 459 which is fixed and secured to the Housing frame.

By such construction therefore the arm will be rotated or rotates to 90° per each revolution of the maincrankshaft 424 which means will rotate the Rotor to 60° as it may required for additional rotation per each revolution of the maincrankshaft in order to obtain speed ratio of 1 : 2.

The maincrnakshaft 424 is also provided with lubricating oil holes through the centre 453 for sufficient lubrication of the roller bearing 441 which is installed within the hollow shaft of the pinion gear 438, and also to lubricate the rotating seal assembly consisted of a coil spring 457 and carbon seal 446/C and stationary seal seat and rubber gasket 458, and retaining ring 459. Both sides of the maincrankshaft 424 will be firmly mounted to the front -ball bearing 444/F and rear ball bearing 444/R to have a snap ring 459 and closed by end cover 445 after given with sufficient special lub-oil. In front part, the balance counterweight 464 is fixed and secured to the maincrankshaft 424 by means of locknut 449.

Within the outer part of the Housing there will be fixed magnetic field coil 461, a free wheeling pulley seat assembly 462 which is positioned to a cylindrical roller bearing 456 to cooperate with clutch assembly 455.

The cylindrical roller bearing is fixed and secured to the Housing frame by means of special locknut 460, while the clutch assembly is fixed and secured to the maincrankshaft 424 by means fof front hexagonal nut 465.

In the rear part, the compressor will also be provided with schrader 454 and within the inside part is installed a cylindrical plate valve 463.

Figure 8 is showing a special cutting tool made for the purpose to cut or to shape precisely the radially arcade Housing cavity or flat inner surface either for 2 apex Rotor or 3 apex Rotor.

Such equipment according to the invention will consist of the same shape of the Rotor 221 provided with cutting blade 254 which is fixed or secured by means of bolt and nut 255, which Rotor 221 is mounted to the eccentric hubshaft 223 made in one and integrated with the maincrankshaft 224, and rotated to the speed ratio of 1 : 2 for the 2 apex Rotor or speed ratio of 1 : 3 for the 3 apex Rotor, by means of intermeshing gears as previously described 237 & 238, 247 & 251, 252 & 248, in such a way in accordance to each gearing ratio as it may required for each type of engine.

In such a construction the maincrankshaft 224 will be hold by 2 ball bearings 244 which in the front part will be connected to the pinion locknut 249 and at the rear will be closed by any hex nut.

To drive the cutting tools a pulley 253 will be installed in between the both bearings and fixed to the maincrankshaft 224 by means of inserted key 256

The ball bearing is positioned to the both side of the main frame 257 which is also constructed to accomodate the separate hubshaft of the cluster gears assembly 242 of the one side while for the other side will be supported by a special separate stand 258 which is fixed or secured to the mainframe by means of bolt and nuts.

Figure 9 & 10 are the drawings of the planetary gears system applied to the rotary engine having curved 3 apex Rotor 21 and 2 lobed curved epitrochoid Housing cavity 20, which planet gears according to this invention will be constructed in a cluster gears assembly consisted of a smaller gear 362/I and larger gear 362/II, which will be intermeshed to the sun gear 348 as well as to the outer ring gear 359 to be based on gearing ratio between gear 348 & 362/II fixed at 1 : 2 and between gear 362/I & ring gear 359 fixed at 1 : 4.

The said sun gear is fixed to the maincrankshaft by means of involute spline and strengthen by means of special locknut 349.

Because of the superposition of the planet gears, therefore the arm 360 will be reduced its speed to the ratio of 1 : (2/1 x 4/1) + 1 = 1 : 9 or equal to 40° per each 360° revolution of the maincrankshaft.

By giving ratio of 3 : 4 between pinion gear 38 and internal ring gear 37, therefore the Rotor 21 will be rotated or rotates up to (1 - 3/4) x 360° = 90° on each revolution of the maincrankshaft. The rotation of the arm of 40° as mentioned above will cause the Rotor be given an additional rotation by pinion gear 38 up to 3/4 x 40° = 30° per each revolution of the maincrankshaft. Therefore by adding its own rotation of 90° with the said additional rotation of 30° the Rotor will totally rotate to 90° + 30° = 120° per each revolution of the maincrankshaft, which is exactly according to the speed ratio of 1 : 3 as required by such typical rotary engine having 3 apex Rotor and 2 lobed epitrochoid Housing cavity.

Figure 11 & 12 are the drawing of the typical rotary engine having 3 apex Rotor with 6 lobed outer surfaces and 2 lobed epitrochoid Housing cavity, and the Rotor is fixed at speed ratio of 1 : 3 with the maincrankshaft which motion can be seen from the Figure 11.

By such construction it is now made possible to obtain a wider space within the apex portion to cooperate with the cavity wall for leakage prevention.

Figure 13 & 14 are perspective drawing of the Rotor provided with intermeshing gears in accordance to the invention and the exact position of the apex Rotor at a speed ratio of 1 : 3. For the same size of Rotor compared to the conventional design with stationary pinion gear fixed to the Housing frame, this typical design has a shorter eccentricity as well as shorter horizontal lenth of line c4 - b2 as shown in the Figure 13.

Figure 15 is a perspective drawing of the whole concept of the invention based on silhouetted broken away view to show the Rotor, 121 radial apex seal 128 curved Housing 120, side seal elements 127, internal ring gear 137, pinion gear 138, the intermeshing gears 147, 148, 151 & 152, the maincrankshaft 124 and eccentric hubshaft 123, flywheel 164, inlet passage 166, outlet passage 165 and lub oil tank 195, oil filter 190, cooling fan 180, electric generator 170, etc.

Figure 16 a,b,c & d are drawing for the Kinematic descriptions

KINEMATICS OF THE INVENTION.

Figure 16 a,b,c & d are showing the kinematic of the preferred embodiment of the invention, in which rotary engine, an I.I.G./Internal Involute Gear (400) is fixed to the Rotor (200) and intermeshed to an I.I.G.P./Internal Involute Gear Pinion (500) having a hollow shaft, through which a M.C.S./Maincrankshaft (100) including its integral E.H./Eccentric Hub Shaft (150) will rotates freely.

In Figure 16a the I.I.G.P. (500) is intermeshed with an I.I.G. (400) based on gearing ratio of 2 : 3 which I.I.G.P. (500) to have a hollowshaft, through which the M.C.S. (100) can rotates freely.

In such a case the I.I.G.P. (500) is fixed or secured to its Housing frame as conventionally constructed.

Based on such gearing ratio of 2 : 3, therefore every revolution (360°) of the M.C.S.(100)/E.H.S.(150), the Rotor (200) /I.I.G. (400) will be rotated or rotates to (1 - 2/3) x 360° = 120°, which means the speed ratio between the Rotor (200)/I.I.G. (400) against the M.C.S.(100)/E.H.S.(150) is 120° : 360° = 1 : 3.

The contact points of the both pitch circles are consisted of point C which belong the the pitch circle of I.I.G. (400) and point P which belong to the pitch circle of I.I.G.P. (500).

In Figure 16a the M.C.S.(100)/E.H.S.(150) is rotated to 90° ($\angle\alpha = 90°$) and therefore the centre point of E.H.S.(150) which is O3 will move to $O3^1$.

Because the I.I.G.P. (500) is stationary, therefore point P will still at its original position while the point C will move to new position of C^β ($\angle\beta = 1/3 \times \angle\alpha = 30°$).

In Figure 16b, the I.I.G.P. (500) is intermeshed with I.I.G. (400) based on gearing ratio of 3 : 4 and the I.I.G.P. (500) is still fixed or secured to its Housing frame. By such gearing ratio of 3 : 4, therefore every revolution of M.C.S.(100)/E.H.S. (150) the Rotor (200)/I.I.G.(400) will be rotated or rotates to : (1 - 3/4) x 360° = 90°, in this Figure 16b, as because the M.C.S.(100)/E.H.S.(150) is rotated only for 90°, therefore point C will move to point C^φ, and point P is still maintain in its original position ($\angle\varphi = 1/4 \times \angle\alpha = 22{,}5°$).

But because the speed ratio of the Rotor (100) must be maintained 1 : 3 if using 3 apex portion Rotor with 2 lobed epitrochoid Housing cavity, therefore the new position of point C must be in the point C^β ($\angle\beta = 30°$).

The distance between C^φ and C^β in this Figure 16b can be reached only by the Rotor (200)/I.I.G.(400) if during the said above rotation it is accelerated through the intermeshing gears installed between the Rotor (200) and the M.C.S.(100) by which intermeshing gears, therefore the Rotor (200) will always able to reach in due time and accurate position of C^β on each revolution as mentioned above. Such additional distance of C^φ to C^β if mentioned in fractional figures is designated as a/b in the Raser Formula in the said application.

In Figure 16b the distance of C^φ to C^β is 30° - 22.5° = 7.5° per 90° of shaft rotation. Therefore if calculated by a complete revolution of 360° the same said above distance will be (360° : 90°) x 7.5° = 30° or represent 1/12 of shaft revolution. Therefore in such a case as mentioned in Figure 16b the a/b quotient is equal 1/12 which equation has been used and described in the previous Summary of the Invention of the previous application (E.P.O. No. 87.201780.1, US Patent Serial 098.189). The said above a/b equation is designed for the purpose of maximum use of the space available and minimum gearing to be installed in the engine.

There are so many variation in determining the gearing ratio for such same purpose but only few that could save the space and minimum gearing as mentioned above.

If the Raser formula is not used to calculate the gearing as explained above, there is possibility that the a/b quotient can not be met precisely by any combinations of gears installed, and therefore consequently will cause the outer envelope of the Rotor's rotation will not shape exactly to the same of the 2 lobed epitrochoid Housing cavity and will not be able to maintain the permanent clearance during all relative rotations between each apex portions of the Rotor (200) and the Housing wall (11) Such permanent clearance during all relative rotation is made possible only if the Rotor (200) always maintain the speed ratio of 1 : 3 with its M.C.S. (100).

Furthermore the invention is also applicable to any other rotary type such as 2 apex Rotor or 4 apex Rotor, which for the purpose of simplicity the basic ratio for the specific type of rotary (such as 1/2 for 2 apex Rotor, 2/3 for 3 apex Rotor and 3/4 for 4 apex Rotor), hereinafter will be designated or referred to as p respectively, as can be seen from the formula of this invention.

The intermeshing gears which are installed between the Rotor (200)/I.I.G.(400) and the M.C.S. (100) will cause the I.I.G.P. (100) to rotate in the same direction in order to be able the point of C^φ to reach the position of the point C^β based on speed ratio of 1 : 2 for 2 apex Rotor, or 1 : 3 for 3 apex Rotor

or 3 : 4 for 4 apex Rotor.

The movement of the I.I.G.P.(100) is shown in the Figure 16 c and 16 d.

In Figure 16c, the I.I.G.P. (500) is constructed in one hollow shaft with one of the intermeshing gear through which it will be rotated or rotates according to its proper speed ratio.

Because the a/b quotient of 1/12 represent for such rotary engine with I.I.GP. (500) and I.I.G.(400) having gearing ratio of 3 : 4, therefore the I.I.G.P,(500) will be rotated or rotates to the distance of :

1/12 x 4/3 x 360° = 40° per each full revolution of the M.C.S. (100)/E.H.S. (150) or in fractional figure of 1/9.

Such fractional figure of 1/9 can be easily splitted into 1/3 x 1/3 which means that the further intermeshing gears between the I.I.G.P.(500) and M.C.S.(100) is fixed to gearing ratio of 1 : 3 and 1 : 3 respectively. (minimum gears for space efficiency).

In Figure 16c because the M.C.S. (100) is rotated only for 90° therefore the new position of the P will be P1 which is 90°/360° x 40° = 10° in the same direction and the actual P position after every full revolution will be P2 which is at 40° away from it original position.

In rotary engine with 2 apex Rotor and 1 epicyclic Housing cavity the figure is 1/4 which can be easily splitted into fixed gearing ratio of 1 : 2 and 1 : 2 respectively while in 3 apex Rotor with 4 lobed epitrochoid Housing it will be 1/16 which can be easily splitted into fixed gearing ratio of 1 : 4 and 1 : 4 respectively.

Because based on the above gearing ratio of 3 : 4 between the I.I.G.P. (500) and its intermeshing I.I.G. (400) the diameter of the M.C.S. (100) can be constructed larger than the conventional model.

Such larger M.C.S. (100) other than the conventional model can be seen from the Figure 16d, by which, naturally the engine will able to carry more loads etc.

Claims

1. A rotary engine, such as a rotary internal combustion engine, a rotary pump, a rotary compressor, or the like, comprising of a radially curved or arcaded Housing cavity in the form of epicyclic or 2 and 3 lobed epitrochoidal inner wall shapes and a n + 1 radially curved apex Rotor installed within the said cavity and movable there around in a planetary fashion, n being 1, or 2 or 3 ..... and a maincrankshaft provided with an eccentric hubshaft - supporting said curved Rotor, and characterized in that the engine further comprises of a transmission to be installed in between the curved Rotor and the maincrankshaft, which transmission gears are to consist of :

a. an internal ring gear which is fixed or secured to one side of the curved Rotor by means of bolt and nut or the like.

b. a first cluster gears assembly having a hollowshaft for free wheeling with in the said maincrankshaft by means of roller bearings, to consist of a -smaller gear which will function as the pinion gear to the said internal ring gear, and a larger gear which will be intermeshed to the second cluster gears assembly.

c. a second cluster gears assembly having a separate crankshaft and consist of a smaller gear which is intermeshed to the said larger gear of the first cluster gears assembly, and a larger gear which is intermeshed to the final pinion gear fixed within the maincrankshaft.

d. a final pinion gear which is fixed or secured to the maincrankshaft by - means of involute spline or other and strengthen by a special locknut or the like.

e. for 2 apex Rotor the internal ring gear and pinion gearing ratio is 3 : 2 and
for 3 apex Rotor the internal ring gear and pinion gearing ratio is 4 : 3 and
for 4 apex Rotor the internal ring gear and pinion gearing ratio is 5 : 4.

f. for 2 apex Rotor the intermeshing gears ratio are 1 : 2 and 1 : 2,
for 3 apex Rotor the intermeshing gears ratio are 1 : 3 and 1 : 3,
for 4 apex Rotor the intermeshing gears ratio are 1 : 4 and 1 : 4,
which the smaller ratio refers to smaller gear and larger ratio refers to the larger gear.

2. A rotary engine, such as claimed in the claim 1, but instead of constructing the Rotor radially curved and radially arcaded Housing cavity, in this - claim will be constructed to have a flat outer surfaces Rotor and Housing cavity which is parallel to the axis shaft.

3. A rotary engine, such as claimed in the claim 1 & 2, but instead of providing it with intermeshing gears between the Rotor and maincrankshaft, in this claim will be provided with a planetary gears system or epicyclic gears train, by which therefore the said pinion gear will be constructed and made integral in a cluster arm & gear assembly, to have a hollow shaft for free -wheeling within the maincrankshaft by means of roller bearings, and which arm will be provided with 3 armshaft to hold 3 units of free wheeling planet gears which will be intermeshed to the sun gear as well as to the outer ring gear. The said sun gear will be fixed and secured to the maincrankshaft by - means of involute spline or other, and strengthen by means of special locknut or the like, while the outer ring gear will be fixed within the outer part of - the Housing frame by means of bolt & nuts or the like.

For the rotary engine with 2 apex Rotor, the gearing ratio between the outer ring gear, the planet gears and the sun gear are fixed to 3 : 1 : 1 provided -the gearing ratio of the internal ring gear and the pinion is fixed to 3 : 2.

For the rotary engine with 3 apex Rotor, the planet gears will be made and constructed in a cluster gears assembly to consist of a smaller gear and larger gear. The smaller gear will be intermeshed to the outer ring gear, while the larger gear will be intermeshed to the sun gear. The gearing ratio between the outer ring gear and the smaller planet gear & the larger planet gear and the sun gear are fixed to 4 : 1 & 2 : 1 provided that the gearing ratio of the internal ring gear and the pinion is fixed -to the ratio of 4 : 3.

For the rotary engine with 4 apex Rotor, the similar gearing construction will be made based on gearing ratio of the outer ring gear and the smaller planet gear & the larger planet gear and the sun gear to be fixed to : 5 : 1 & 3 : 1 provided that the gearing ratio of the internal ring gear and the pinion is fixed to the ratio of 5 : 4.

4. A rotary engine, such as claimed in the claim 3, that for the purpose to obtain more various gearing combinations as it may required from one type to the other type, therefore the required transmissions based on different gearing ratio will be constructed in accordance to the application of the formula as follows :

$$\frac{\text{I.I.G.P.}}{\text{I.I.G.}} - \frac{a}{b} = p$$

in which :

I.I.G.P. refers to the internal involute gear pinion,

I.I.G. refers to the internal involute gear,

a/b designates to the additional rotation of the internal involute gear on each revolution of the maincrankshaft,

p designates to the basic ratio for each specific type of the rotary engine, being 1/2, 2/3, 3/4 for an epicyclic, or 2 or 3 lobed epitrochoid Housing cavity respectively.

5. A rotary engine, such as claimed in the claim 4, wherein any transmission is designed in such a manner that if a/b quotient is positive, the internal involute gear pinion rotates in the same direction of the maincrankshaft, and if it is negative, will rotates in the opposite direction of the maincrankshaft.

6. A rotary engine, such as claimed in the claim 5, particularly for the 3 apex Rotor type, that beside as conventionally designed, in this claim will be constructed with 3 apex Rotor and 6 lobed outer surface either of the curved or flat type surfaces.

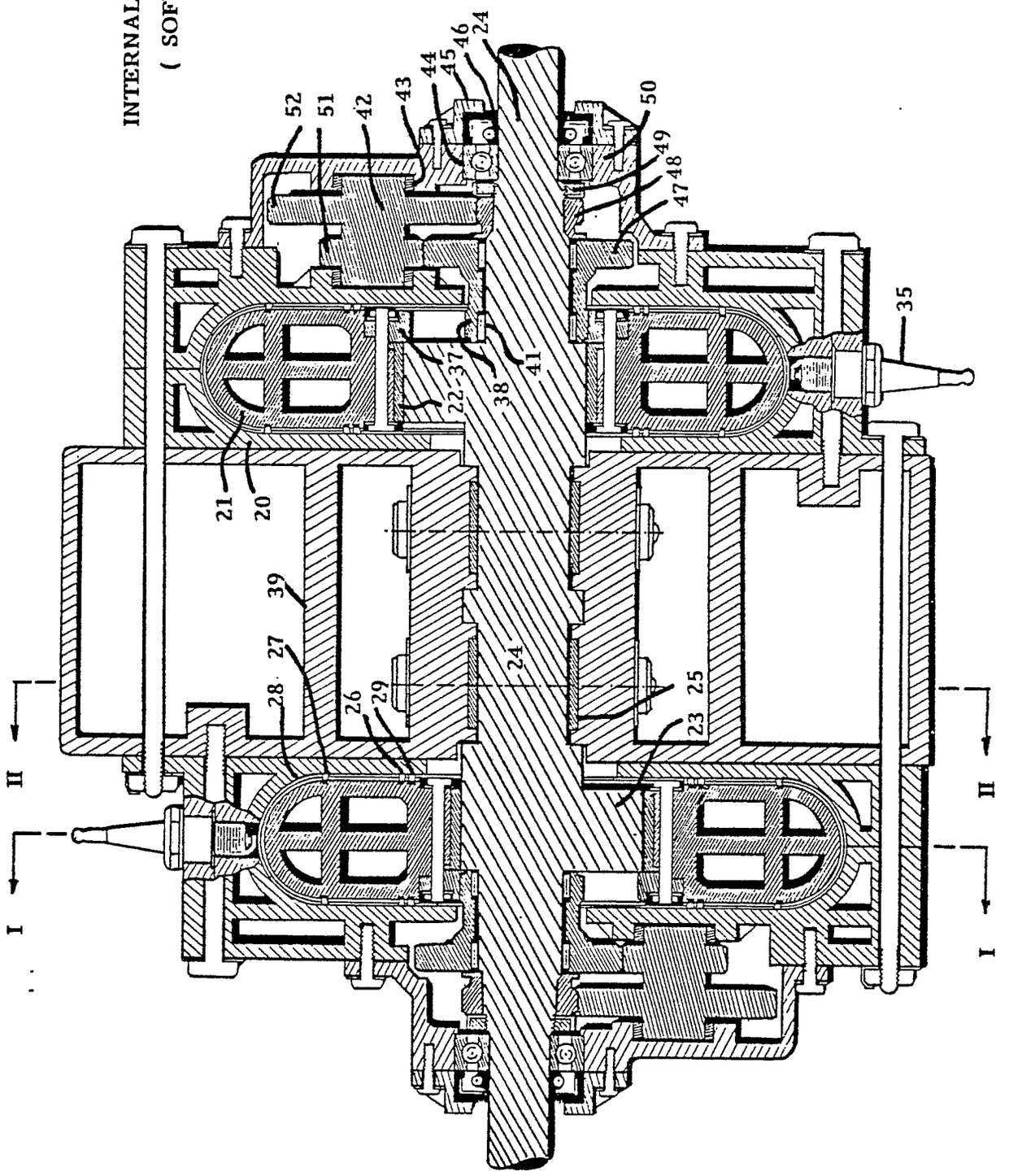
7. A rotary engine, such as claimed in the claim 6, in which within the outer part of the Housing will be provided with intake and outlet passages port for communicating the concern working chambers, with or without valves, combustion by means of spark plug and or fuel injector, using any kind of fuels, any type of cooling system, any kind of good quality lubricating oils, with or without sealing elements between the cooperating shape, etc.

8. A rotary engine, as claimed in the claim 7, wherein the transmission comprises of one type or more gears such as involute or hypoid or any other kind of gears suitable for such mentioned principles which is fixed to or mounted on the maincrankshaft and other cooperating parts, intermeshed each other or not, one and another in order to maintain the rotation of the Rotor and the maincrankshaft in accordance to the predetermined ratio such that the outer envelope of the rotating rotor will make the desired shape at the punctual timing and proper speed ratio.

9. A rotary engine, as claimed in the previous claims, including all type of vehicles, equipments or apparatus provided with such rotary engine or rotary equipments or machines, special cutting device, rotary compressor rotary pumps, or any other rotary system using the same principles which are suitable for any engines, aircraft engines, or any future flying craft engines, using any kind of fuels, for land, sea or air transportations means as hereinbefore described with references to the accompanying drawings and its technical descriptions thereof.

ROTARY
INTERNAL COMBUSTION ENGINE
(SOFYAN ADIWINATA)

FIG. 1

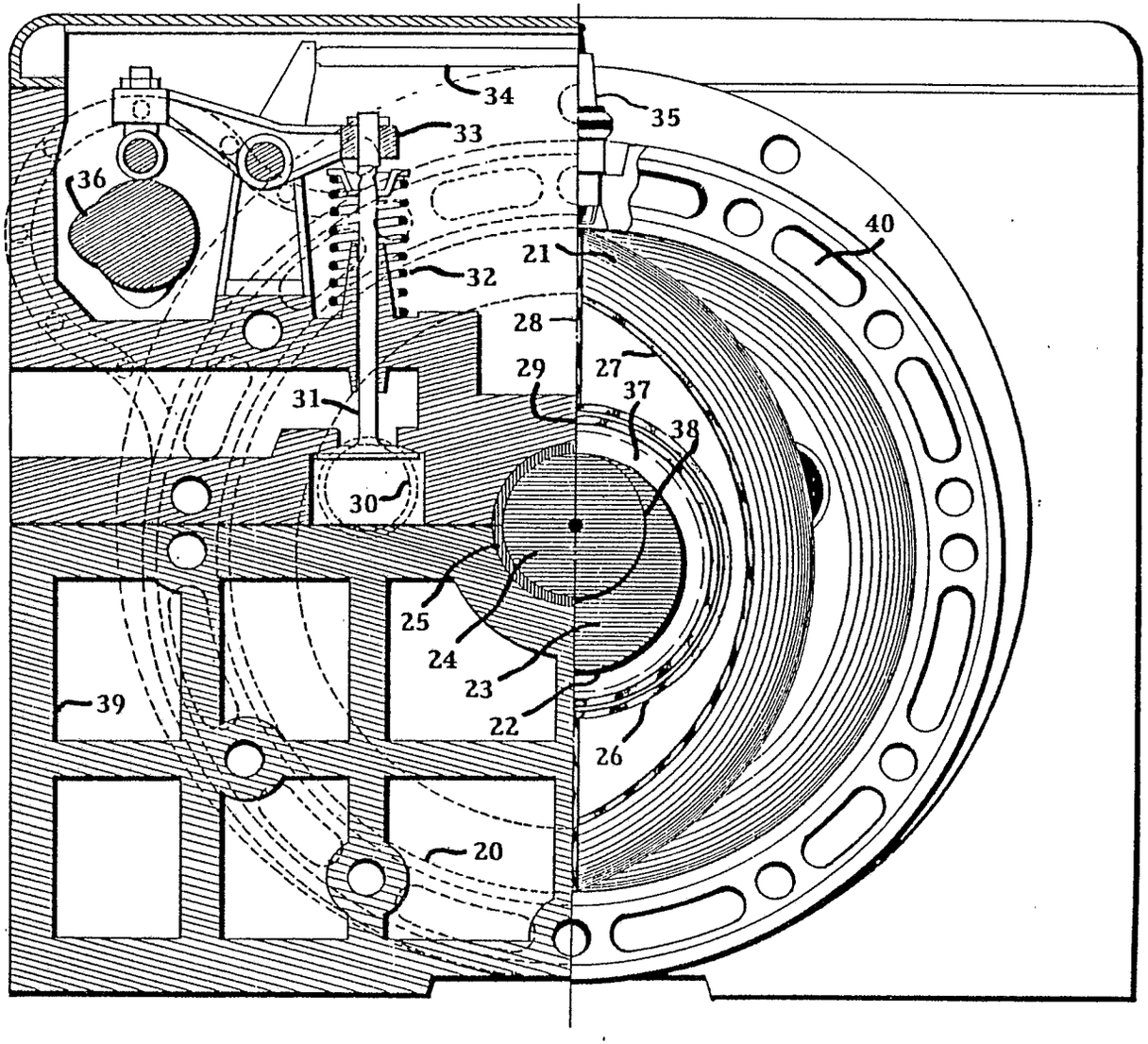


ROTARY

INTERNAL COMBUSTION ENGINE

(SOFYAN ADIWINATA)

FIG. 2



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ROTARY INTERNAL COMBUSTION ENGINE

(SOFYAN ADIWINATA)

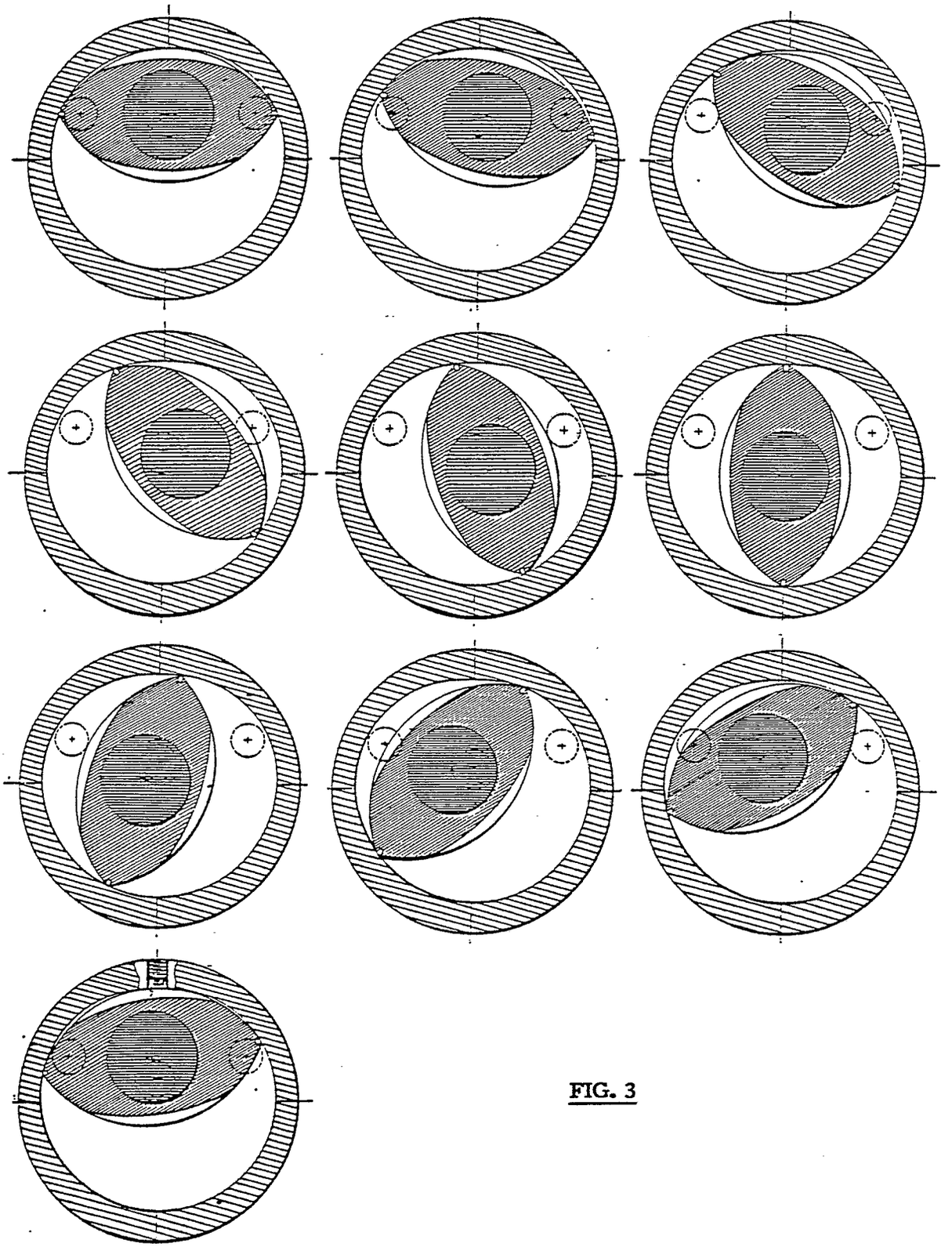

FIG. 3

ROTARY INTERNAL COMBUSTION ENGINE
(SOFYAN ADIWINATA)

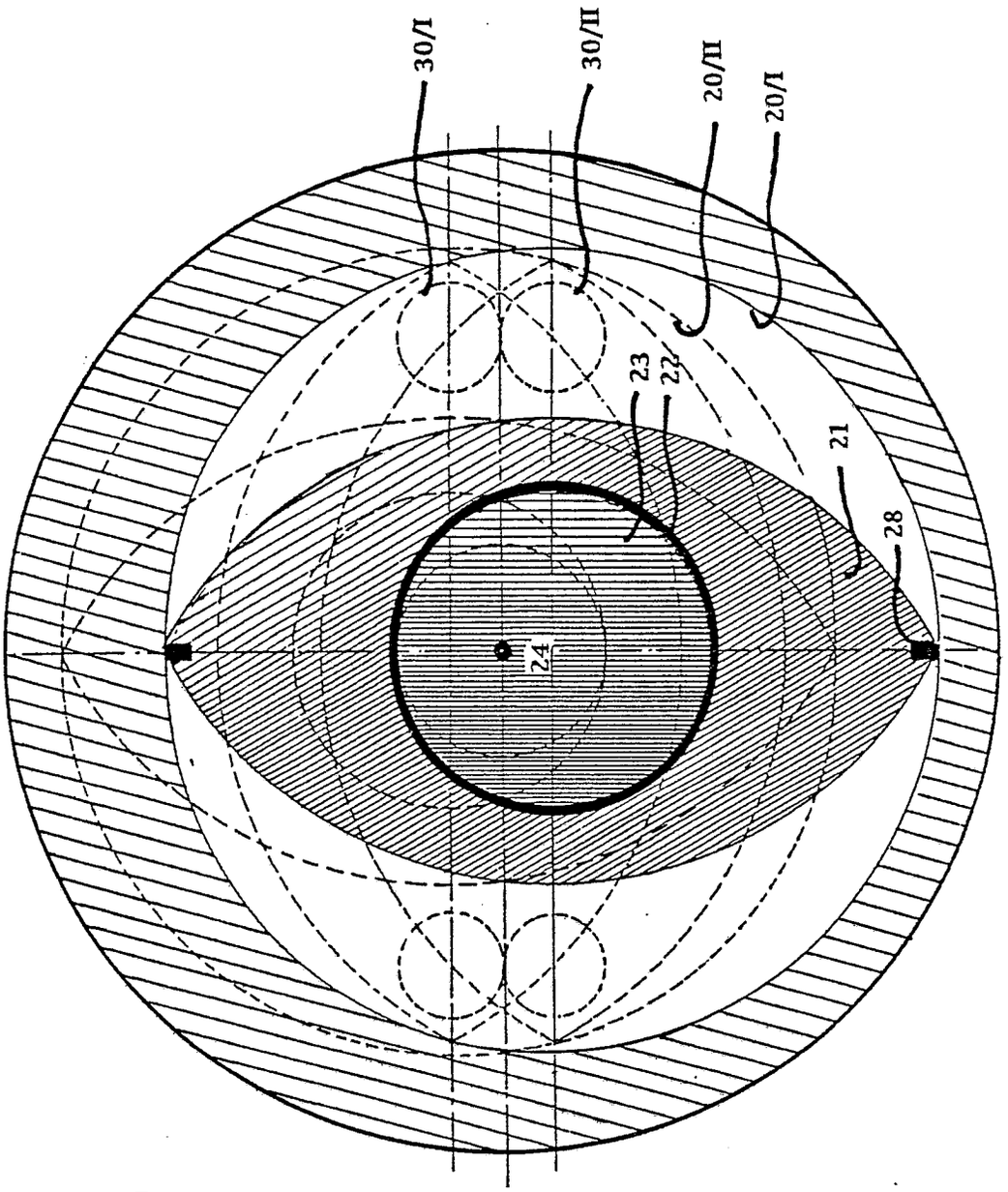

FIG. 4

ROTARY INTERNAL COMBUSTION ENGINE

(SOFYAN ADIWINATA)

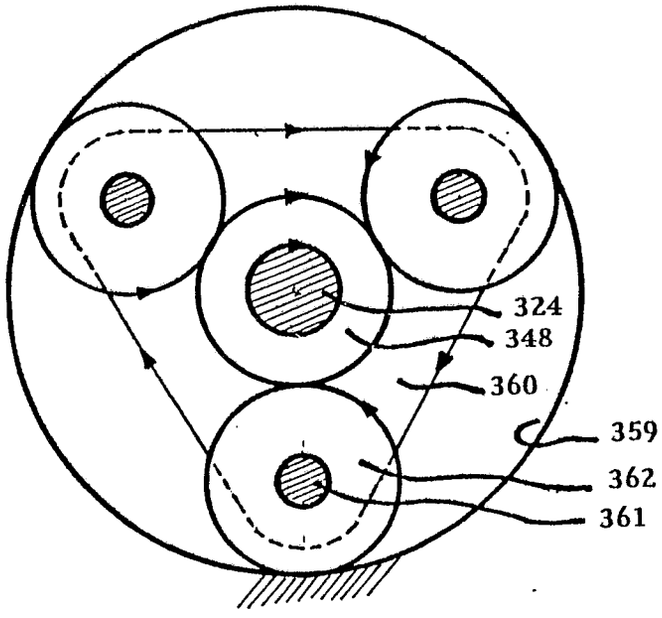

FIG. 5

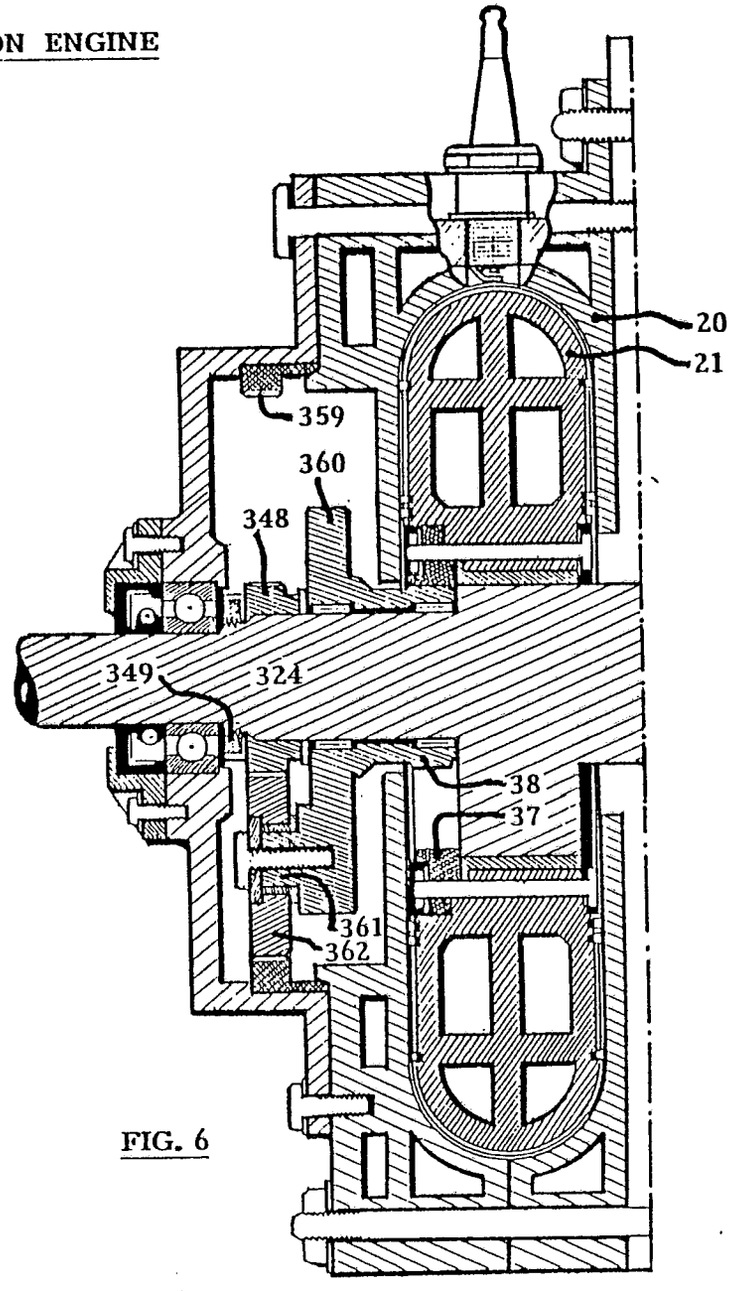

FIG. 6

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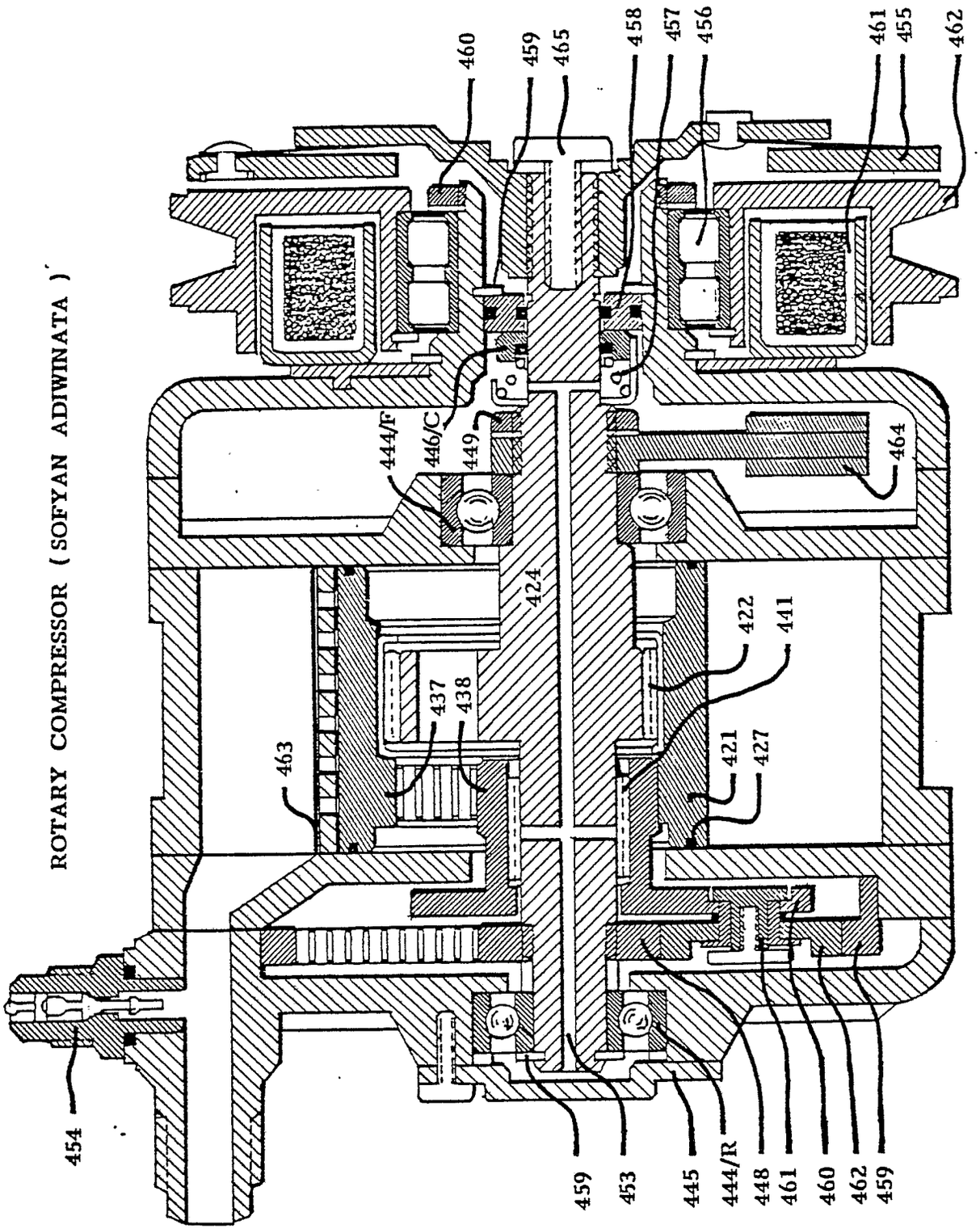
ROTARY COMPRESSOR (SOFYAN ADIWINATA)
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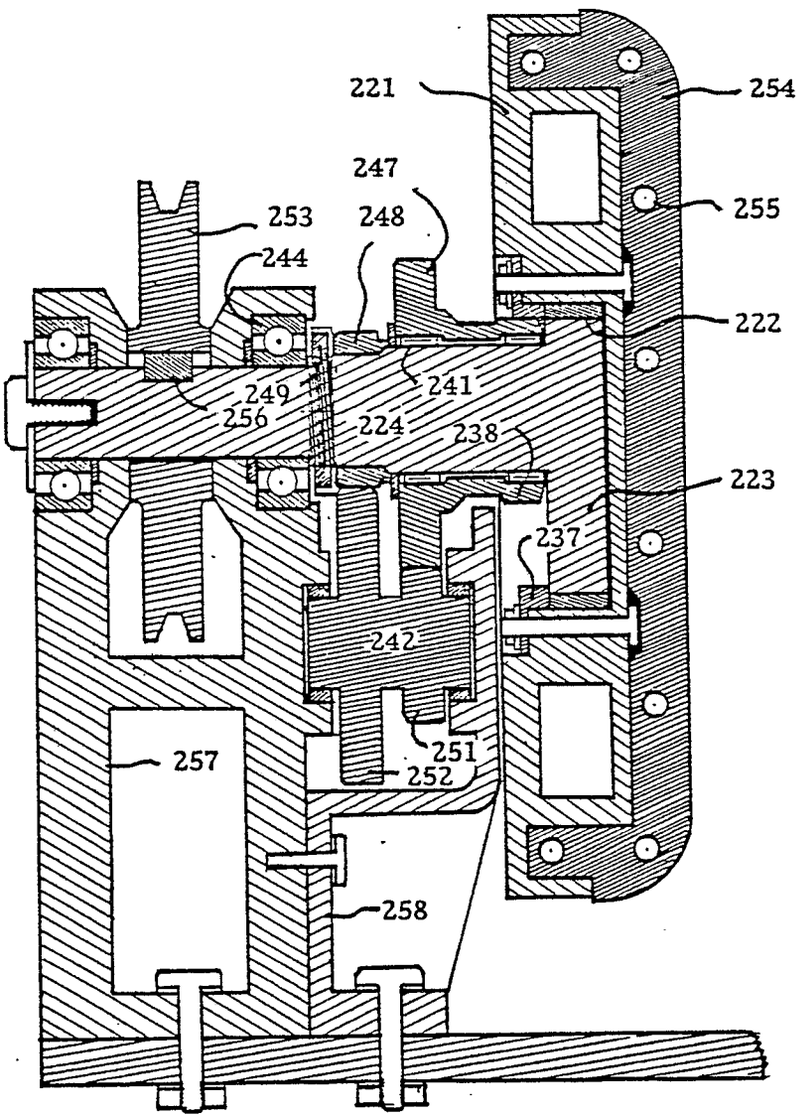
FIG. 7

ROTARY INTERNAL COMBUSTION ENGINE

(SOFYAN ADIWINATA)

FIG. 8



ROTARY INTERNAL COMBUSTION ENGINE

(SOFYAN ADIWINATA)

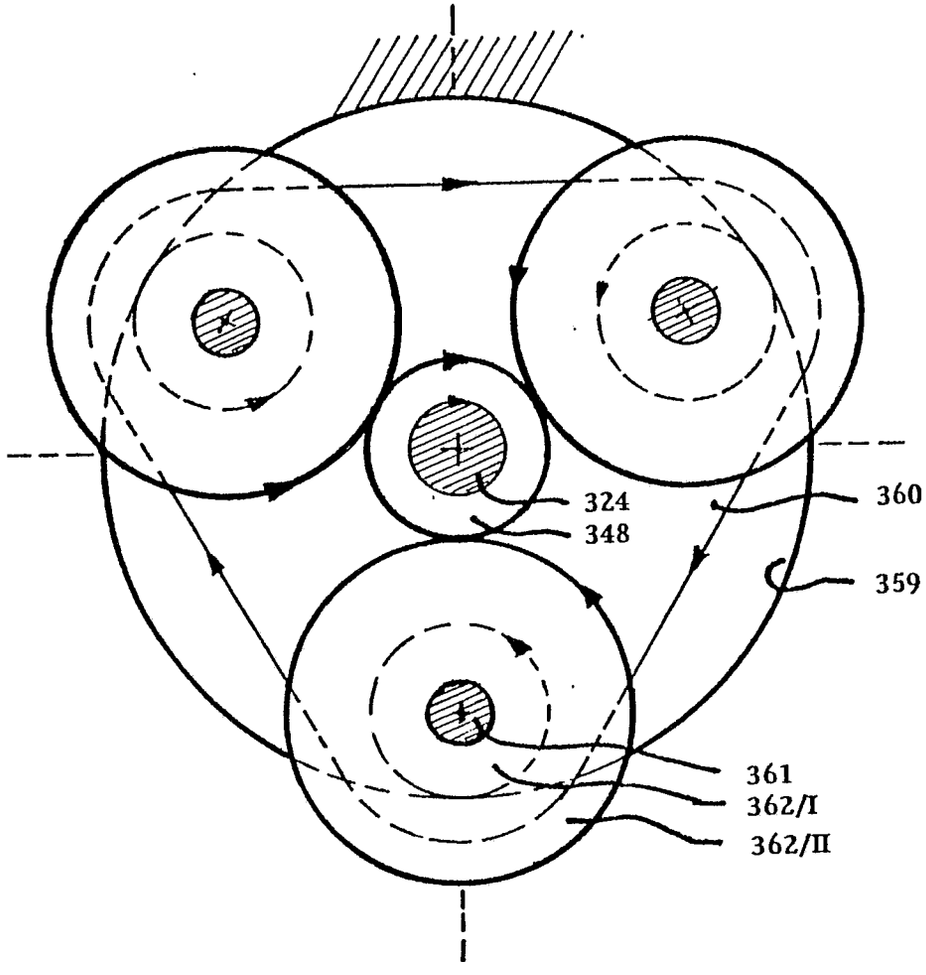


FIG. 9

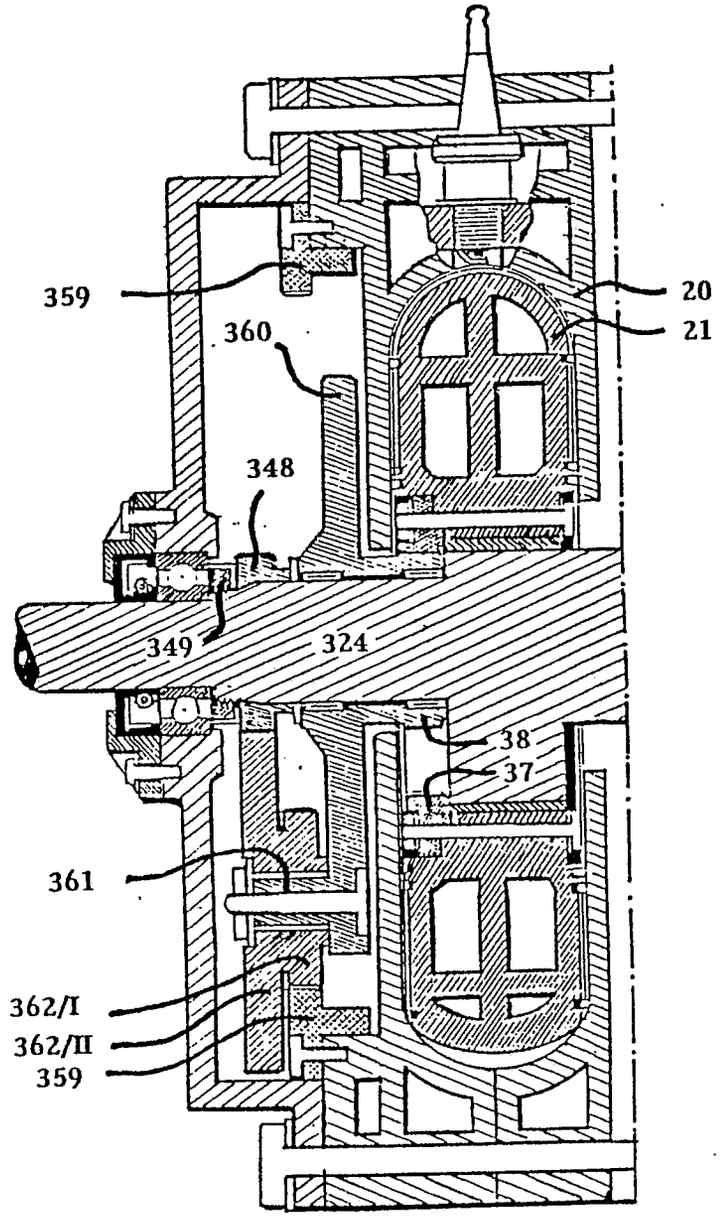


FIG. 10

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ROTARY INTERNAL COMBUSTION ENGINE

(SOFYAN ADIWINATA)

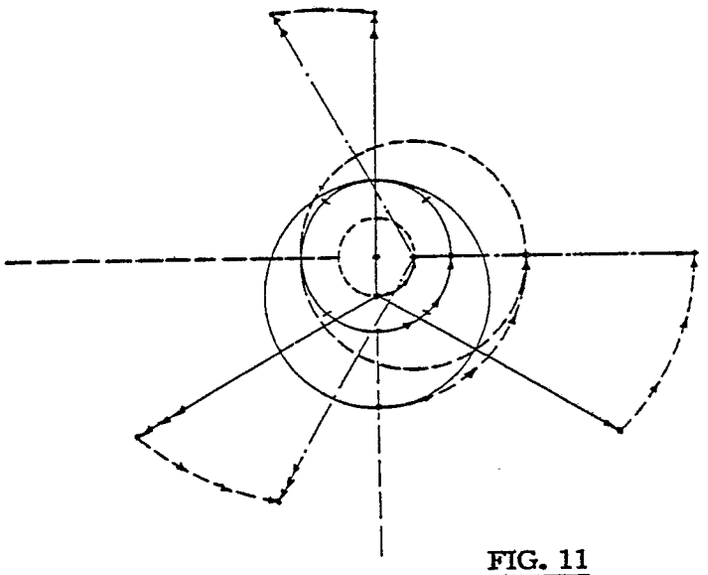

FIG. 11

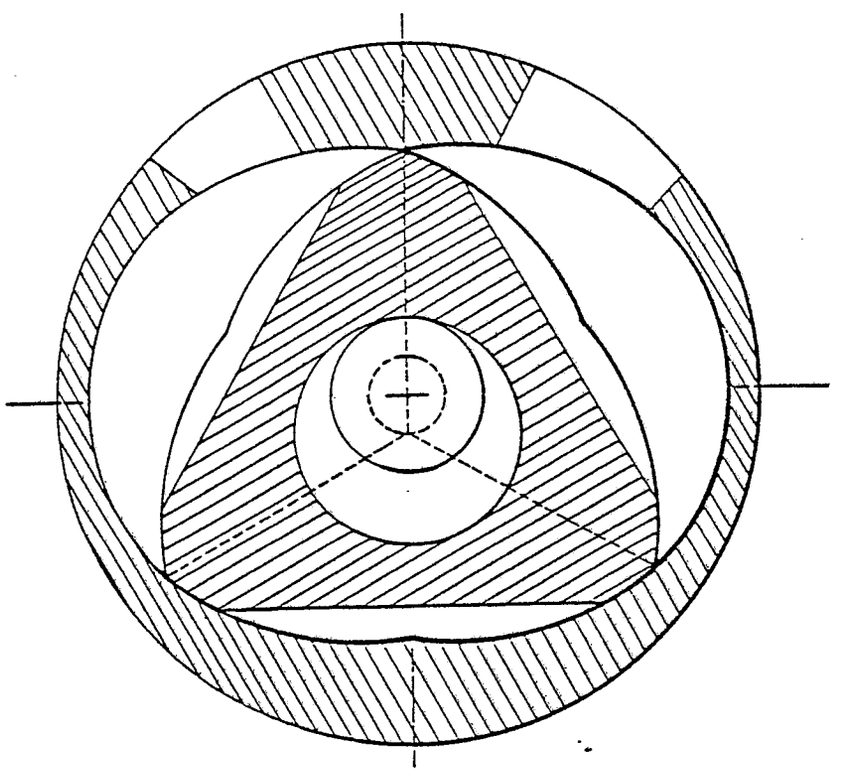

FIG. 12

ROTARY INTERNAL COMBUSTION ENGINE

(SOFYAN ADIWINATA)

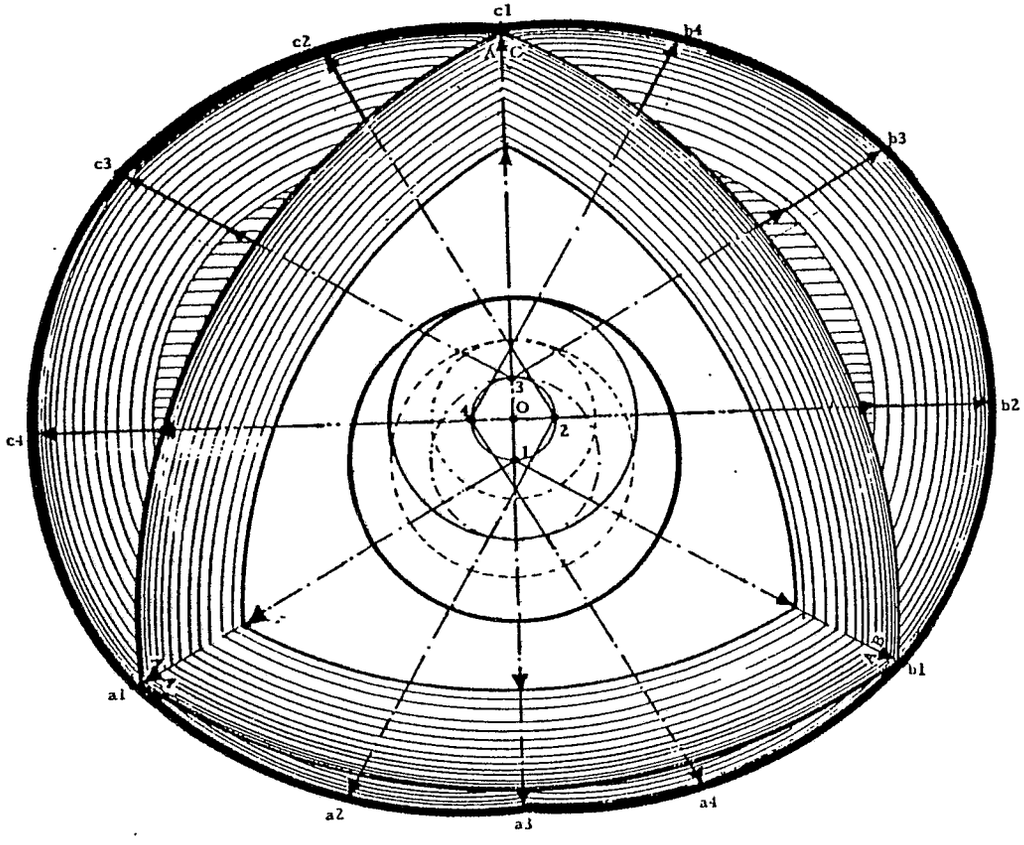

FIG. 13

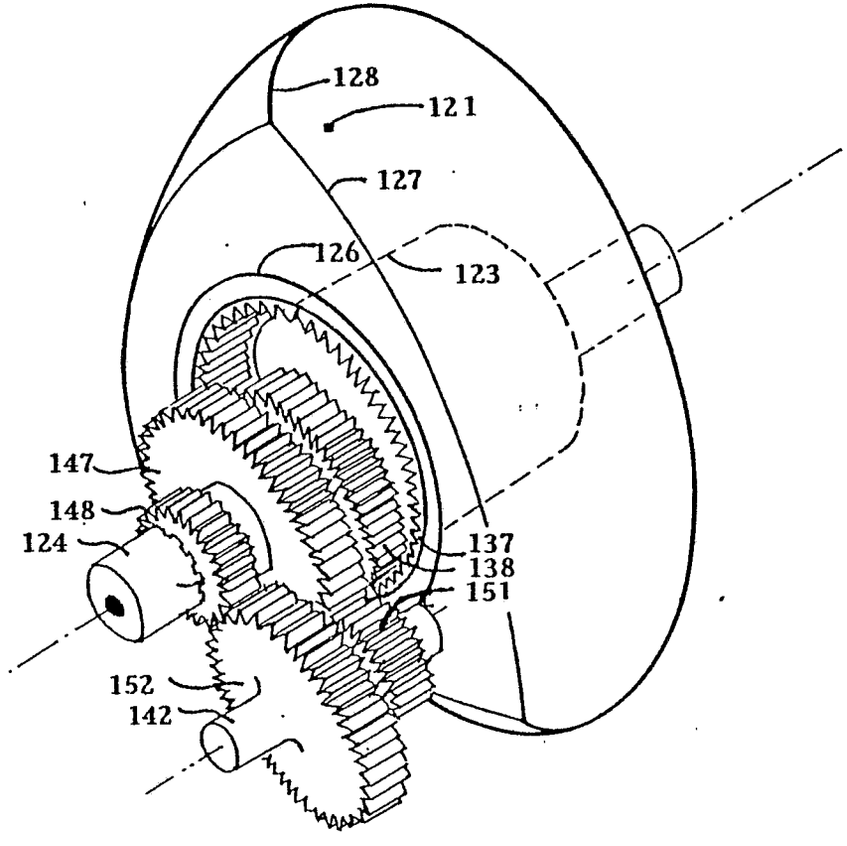

FIG. 14

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ROTARY INTERNAL COMBUSTION ENGINE

(SOFYAN ADIWINATA)

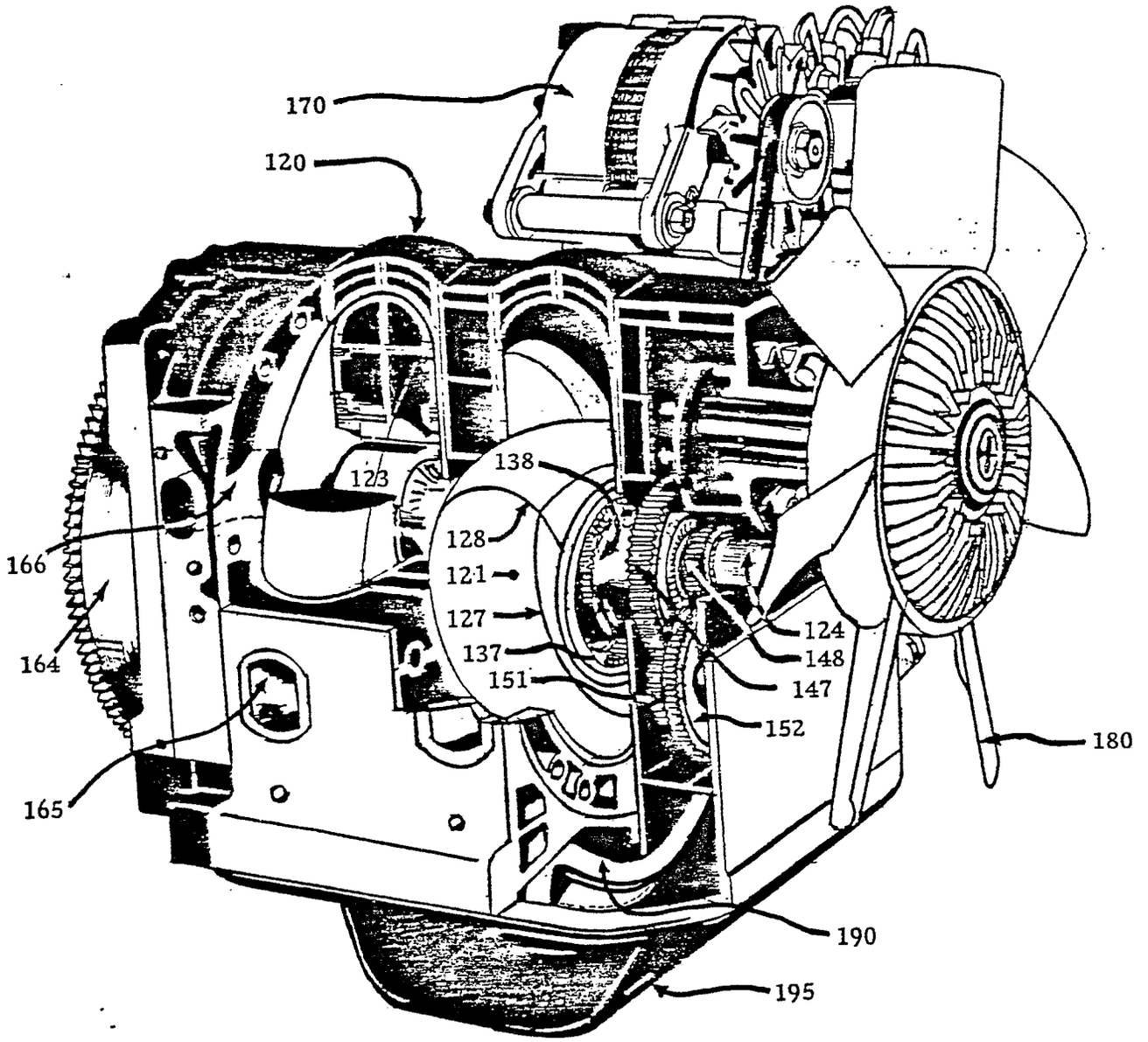

FIG. 15

ROTARY
INTERNAL COMBUSTION
ENGINE

(SOFYAN ADIWINATA)

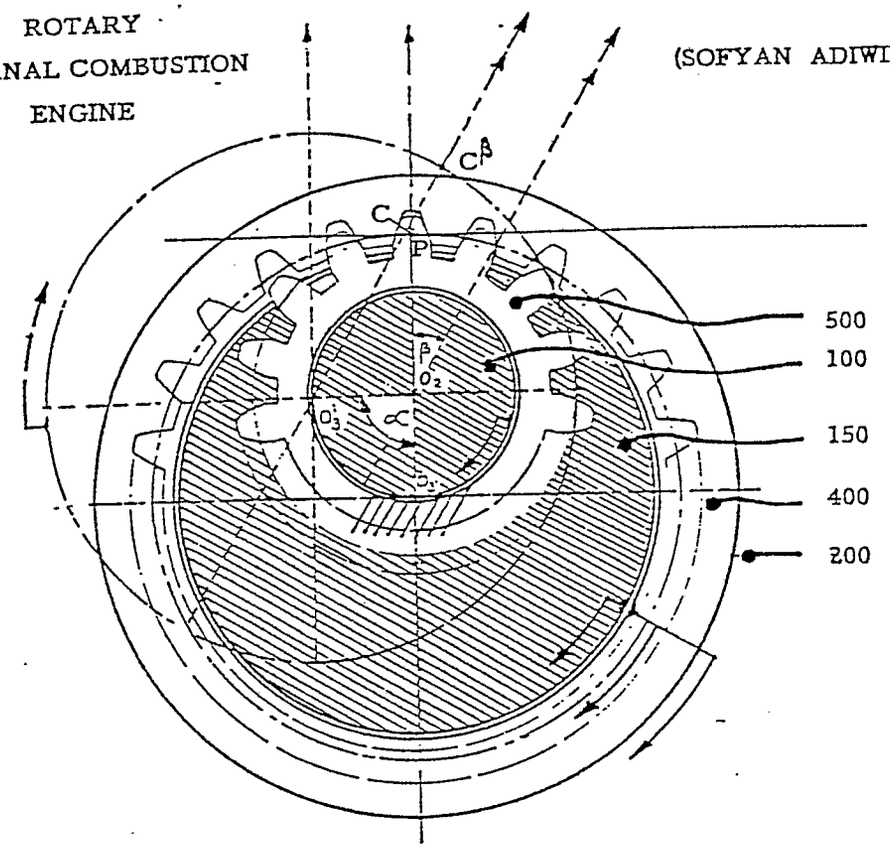

FIG. 16 a.

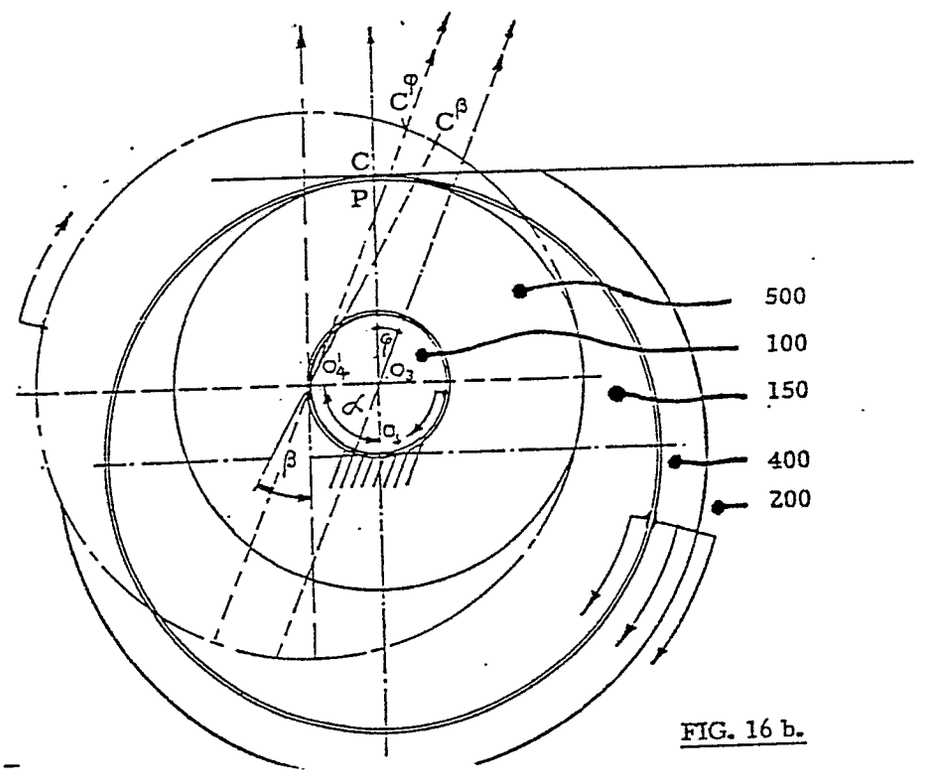

FIG. 16 b.

ROTARY
INTERNAL COMBUSTION
ENGINE

(SOFYAN ADIWINATA)

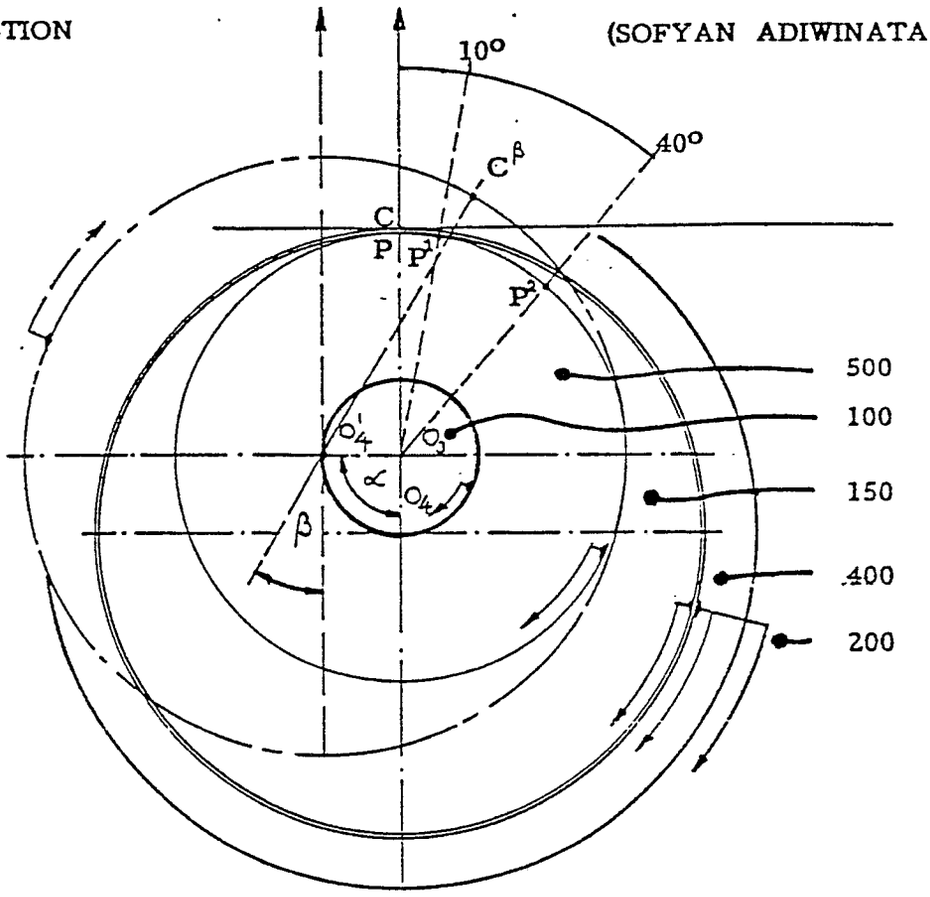

FIG. 16 c.

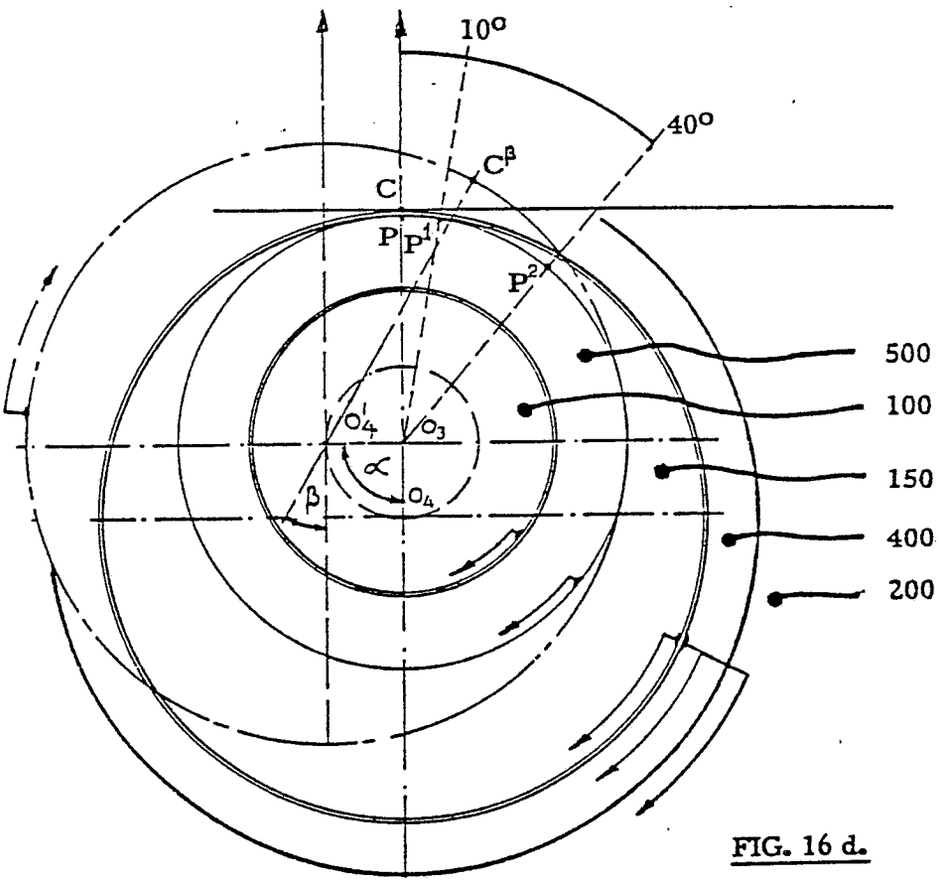

FIG. 16 d.

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 88 81 0635

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	GB-A-2 095 334 (TROCHOID POWER CORP.) * Page 2, line 89 - page 4, line 12; figures 1,2; page 6 *	1	F 01 C 1/22 F 01 C 17/02
Y		3	
Y	DE-B-1 194 636 (BETEILIGUNGS- UND PATENTVERWALTUNGSGESELLSCHAFT) * Column 3, lines 13-50; figures 1,2 *	3	
Y	US-A-3 244 155 (LAUDET) * Columns 3,4; figures *	3	
A	US-A-4 308 002 (DI STEFANO) * Column 1, lines 22-36; column 2, lines 43-52; figures 1,2; column 4, line 64 - column 5, line 16 *	1,7	
A	DE-A-2 853 930 (OTTO) * Page 6, last paragraph; page 7, paragraphs 1,2; figure 2 *	6,7	
X,P	EP-A-0 262 721 (ADIWINATA) * Claims; figures *	1,2,4,5	TECHNICAL FIELDS SEARCHED (Int. Cl.4) F 01 C 11/00 F 01 C 17/00 F 01 C 21/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	27-12-1988	KAPOULAS T.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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