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Williams

[11] **3,882,827**

[45] **May 13, 1975**

[54] **FOUR-PHASE CYCLE PLANETATING PISTON INTERNAL COMBUSTION ENGINE**

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[52] **U.S. Cl.** **123/8.27;** 418/67

[51] **Int. Cl.** **F02b 53/00**

[58] **Field of Search** 123/8.27, 8.31; 418/65, 418/67

[56] **References Cited**

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[57] **ABSTRACT**

A cylindrical piston eccentrically planetates within a cylindrical bore formed in the stator to generate with each cycle, on one side of the piston, proceeding clockwise from 6 o'clock to 12 o'clock, expanding fuel vapor suction and contracting fuel vapor compression strokes and, on the opposite side of the piston, proceeding from 12 o'clock to 6 o'clock, expanding combustion and contracting exhaust strokes. A shaft journaled concentrically on said stator has fixed thereto an eccentric on which the piston is concentrically mounted. A traveling tangential sealing engagement is maintained between the piston and stator bore to progressively generate said strokes. The fuel vapor inhaled and then compressed on said suction and compression strokes is delivered at 12 o'clock at the moment of maximum compression directly into an ignition sub chamber located between 12 o'clock and 1:20 o'clock, and is forthwith ignited by an electric spark. Controlled separation of the free spaces on opposite sides of the piston within the stator bore is effected in the vertical diametral plane of said bore by radially reciprocable vanes and confinement of the fuel charge in the ignition sub chamber pending the ignition of said charge employs separate cam operated radial valves located respectively at 12 o'clock and 1:20 o'clock. The exhaust stroke terminates at an exhaust port provided in the stator at approximately 5:30 o'clock and fuel vapors are fed to the engine through an inlet port located in the stator at approximately 6:30 o'clock.

The piston is tethered by suitable means located at 12 o'clock which restrains rotation of said piston and confines its movement to planetation thereof as aforesaid.

6 Claims, 5 Drawing Figures

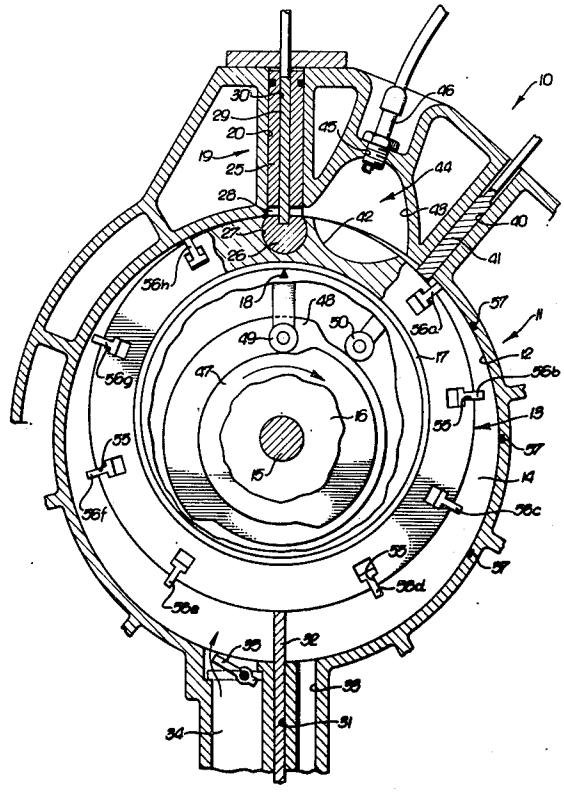


FIG. 1.

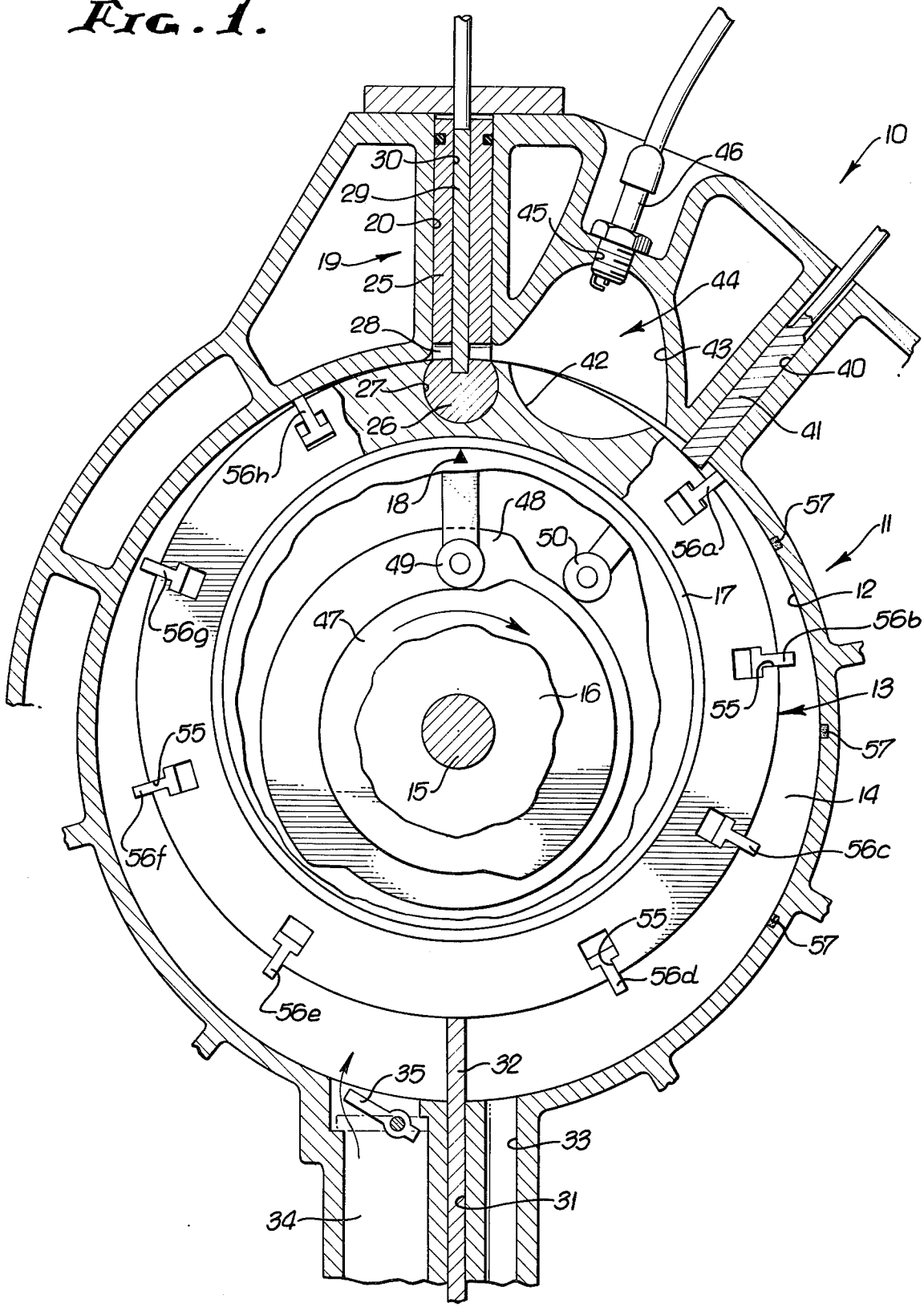

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FIG. 2.

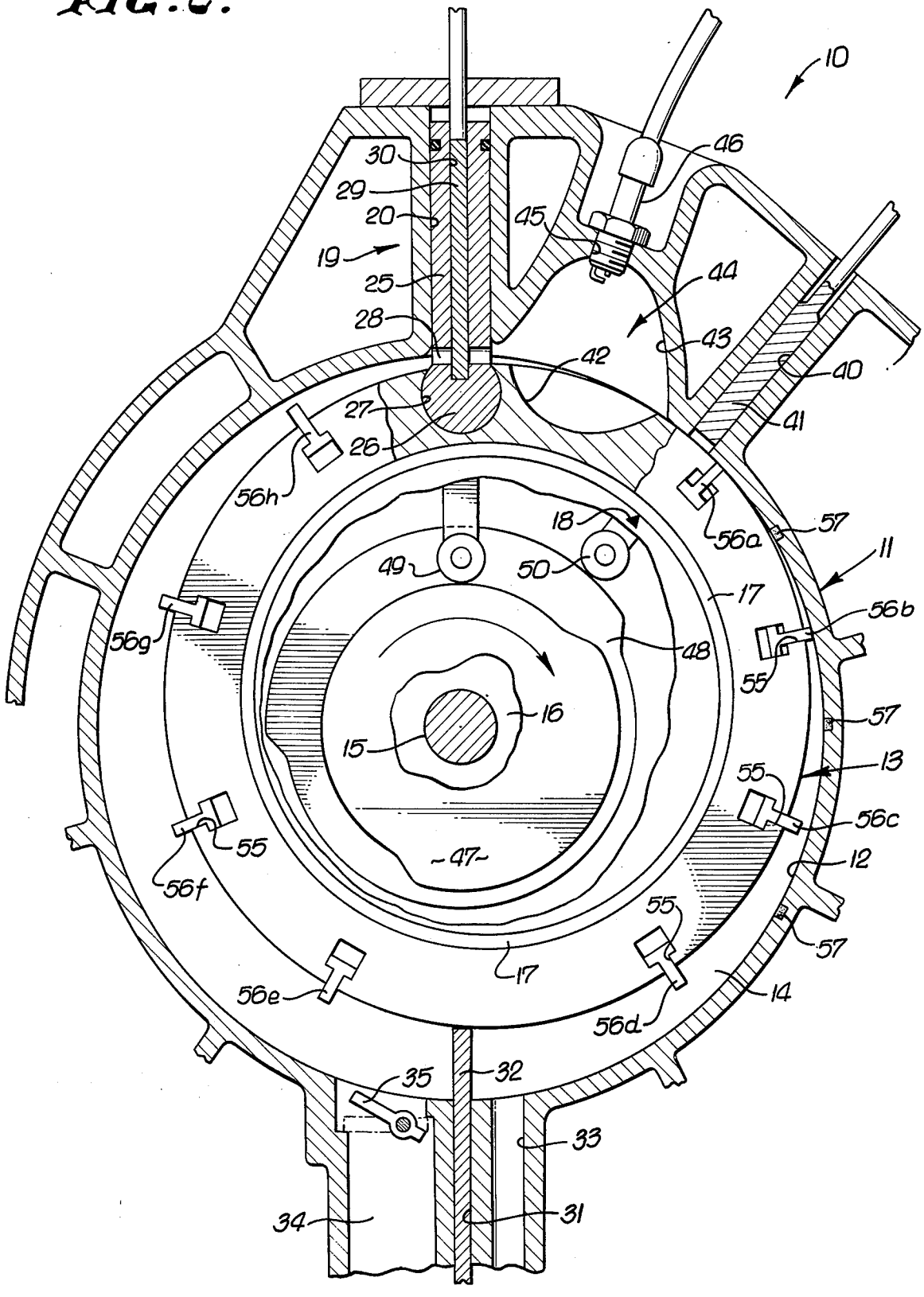

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FIG. 3.

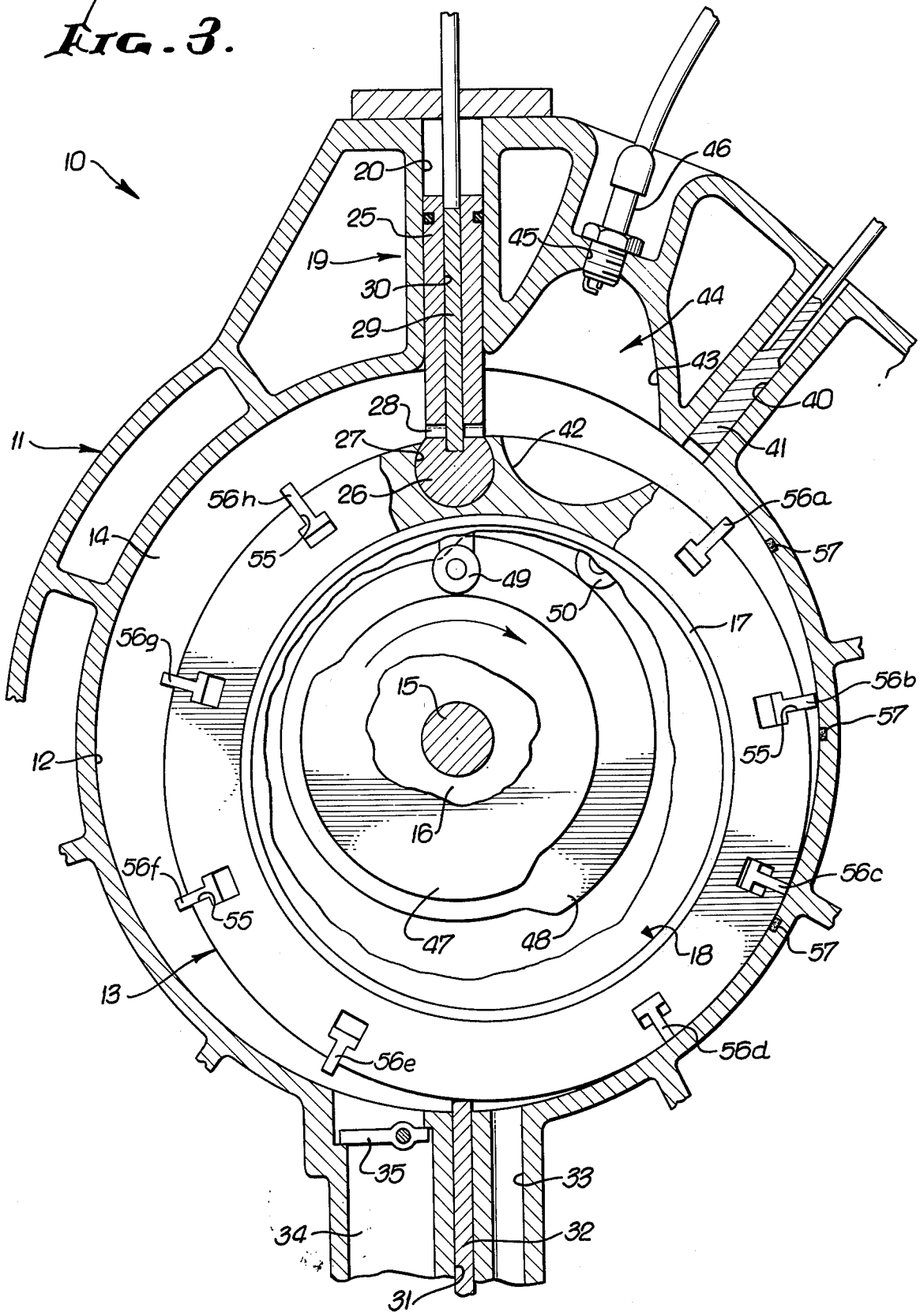

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FIG. 4.

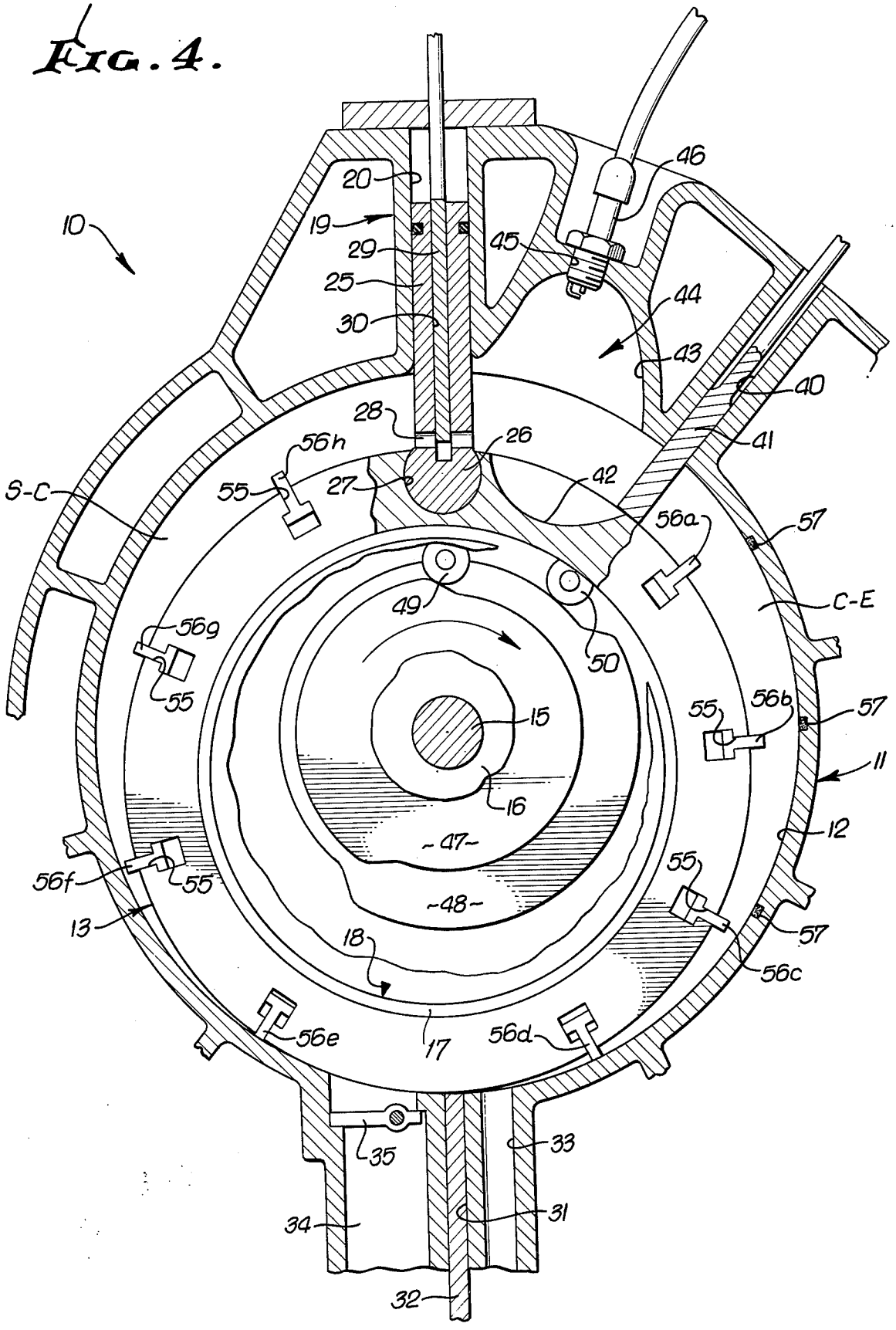
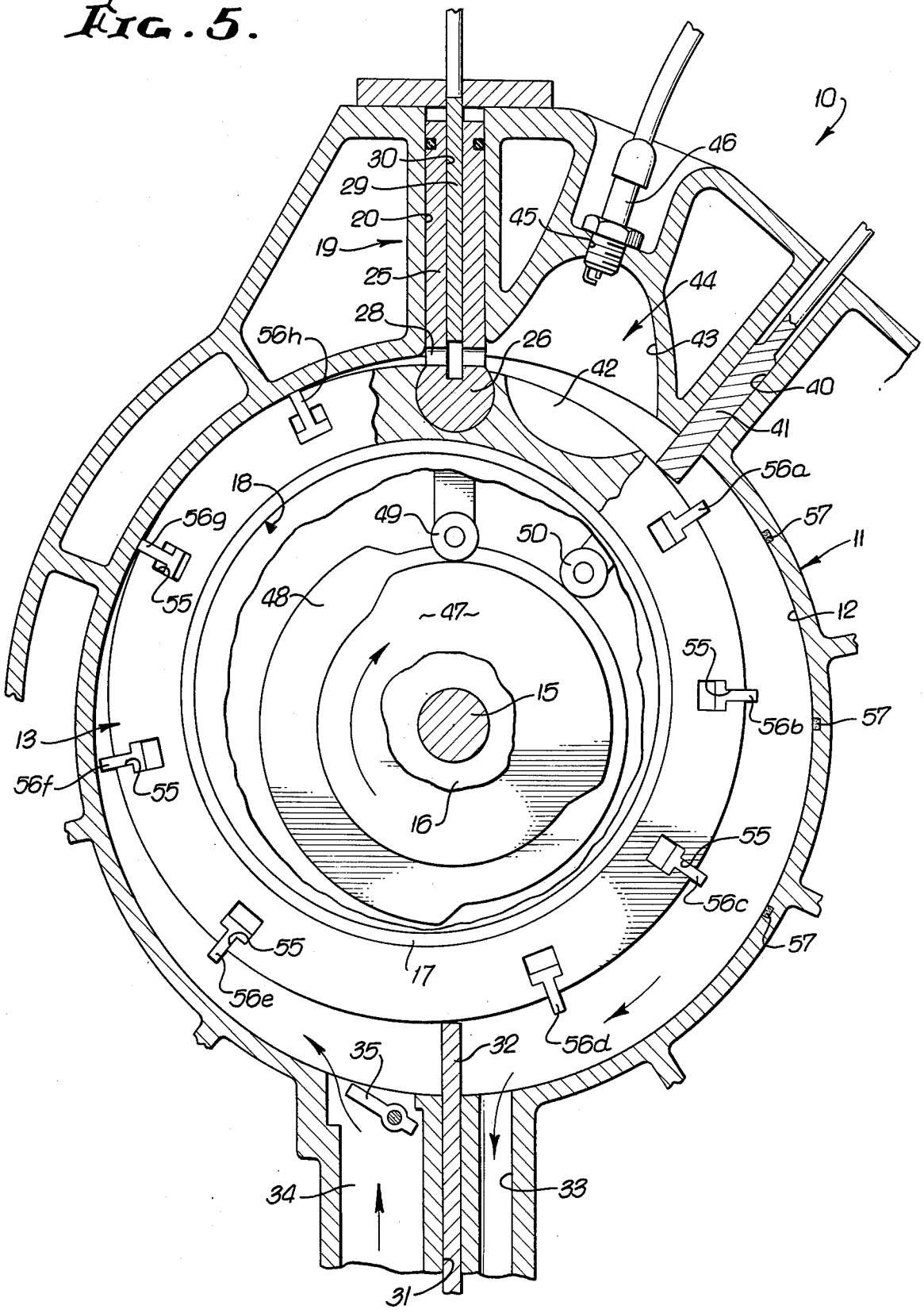

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FIG. 5.


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FOUR-PHASE CYCLE PLANETATING PISTON INTERNAL COMBUSTION ENGINE

SUMMARY OF THE INVENTION

One of the most advanced of the internal combustion engines in general use in automotive vehicles is known as the Wankel rotary engine. It is an object of the present invention to provide an engine which can successfully compete with if not supercede the Wankel engine by outperforming it.

For one thing, the Wankel engine suffers competitively when compared with other engines on the basis of gasoline mileage, mileage run between overhauls and particularly, the miles it will run efficiently before replacement of the engine seals becomes necessary.

It is an object of the present invention to provide an internal combustion engine capable of favorably competing with the Wankel engine to its performance in all of the respects above mentioned. The present invention is particularly superior to other modern automotive engines in the very low rate of seal wear and erosion experienced in the operation of this engine by virtue of the great reduction in friction between the stator bore and the cylindrical piston of this engine over the friction produced in reciprocating engines or in the Wankel engine. The wear factor in the present invention is thus only a very small fraction of that experienced in modern competitive internal combustion engines.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic fragmentary cross sectional view of a preferred embodiment of the invention showing the piston at its 12 o'clock position (dead center).

FIG. 2 is a view similar to FIG. 1 showing the piston of the invention advanced to its 1:20 o'clock position.

FIG. 3 is a view similar to FIG. 2 showing the piston of the invention advanced to its 4:30 o'clock position.

FIG. 4 is a view similar to FIG. 3 showing the piston of the invention advanced to its 6:30 o'clock position.

FIG. 5 is a view similar to FIG. 4 showing the piston advanced to its 10:30 o'clock position.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The drawings illustrate the preferred embodiment of the present invention which comprises an internal combustion engine **10** which includes a stator **11** having a cylindrical bore **12** and an annular cylindrical piston **13** which is mounted for non-rotating planetation within said bore to maintain a constant sealing relation between said piston and said bore and thus performs with each complete power cycle of the engine the four strokes required in any four cycle engine, to wit: a suction stroke; a fuel compression stroke; a combustion stroke; and an exhaust stroke.

For convenience in describing the engine **10** and its operation, the hours of the clock will be used to indicate the point within said bore at which said piston makes tangential sealing engagement therewith at any particular moment during a cycle of the engine.

The bore **12** is closed by parallel end plates **14** which support bearings concentric with said bore in which a shaft **15** journals on which an eccentric hub **16** is fixed. Fitting over the hub **16** is an anti-friction bearing **17** which slideably fits within said annular piston **13**, the outside diameter of the piston **13** being such that when so mounted on the shaft **15**, the peripheral surface of the piston **13** is always approximately in internal tangential contact with the bore **12** at a point disposed directly opposite the high point **18** of the eccentric hub **16**.

The stator **11** and piston **13** are associated together through a tethering means **19** which restricts the rotational movement of the piston **13** to a planetating motion of the piston within the bore **12**. This means also constitutes an abuttment which seals the space between the bore **12** and the piston **13** at 12 o'clock, provides a passage for compressed fuel vapor horizontally through said tethering means and includes a cam controlled valve for closing and opening said passage as required in the operation of the engine. The tethering means **19** includes a flat radial slot **20** formed upwardly from the bore **12** in the stator **11** to slideably accommodate therein an abutment plunger **25**. This plunger has integrally formed thereon along its lower edge a cylindrical head **26** which slides endwise into a correspondingly shaped recess **27** provided in the periphery of the piston **13** to form a pivotal sealing connection between the plunger **25** and said piston. A compressed fuel passage **28** is formed transversely in the plunger **25**, this passage being controlled by a slide valve **29** which is slideably mounted in a central slot **30** formed in the plunger **25**. The slot **20** and abutment plunger **25** are co-extensive in length with the piston **13** and both said piston and plunger make a sealing engagement with the end plates **14**. Thus, throughout the operation of the engine **10** and the resulting planetation of the piston **13** and the vertical reciprocation of plunger **25**, the latter completely closes off the space between the bore **12** and the piston **13** produced by the planetation of the latter in said bore, excepting when the slide valve **29** is opened to allow compressed fuel to flow through the passage **28**. a function which will be made clear in describing the operation of the engine.

At 6 o'clock, the stator **11** is provided with a radial slot **31** for slideably receiving a seal vane **32** which is spring biased inwardly from said slot so as to be held constantly in sealing engagement with the peripheral surface of the piston **13**.

At approximately 5:30 o'clock, the stator **11** is provided with an exhaust port **33** which opens into the bore **12** just in advance of the seal vane **32**.

The stator **11** is also provided with a fuel vapor intake port **34** which opens into bore **12** just beyond seal vane **32** at approximately 6:30 o'clock, said port being fitted with a counterbalanced check valve **35** which opens to admit vaporized fuel into said bore in response to a suction produced in the latter and closes to prevent a backflow of said vapor into the port **34** when said suction terminates at the end of the suction stroke of the engine.

The stator **11** is also provided with a slot **40** coextensive in length with the bore **12** and extending radially outwardly therefrom approximately at 1:20 o'clock. Slideably received in said slot is a valve vane **41** which is spring biased normally into sealing relation with the exterior surface of piston **13** but is subject to being cam retracted into open position as shown in FIG. 2 in a manner to be made clear hereinafter.

Juxtaposed pockets **42** and **43** are formed respectively in the periphery of piston **13** and the stator bore **12** which combine to provide an ignition subchamber **44** which is always in communication with the delivery end of compressed fuel passage **28**. A suitable tapped

hole 45 is provided by the stator 11 through which a spark plug 46 may be inserted into said ignition sub-chamber for ignition of a fuel charge confined therein.

The engine 10 is provided with a conventional electric magneto and timer (not shown) driven by shaft 15 and connected to the spark plug 46 so as to energize said plug in proper timed relation with rotation of the shaft 15 for igniting a fuel charge contained in ignition sub-chamber 44 in the generating of a power stroke in the engine 10. The slide valve 29 and valve vane 41 located respectively at 12 o'clock and 1:20 o'clock on opposite sides of the ignition sub-chamber 44 are both spring biased radially inwardly into closed position and are correlatively opened respectively by cams 47 and 48 fixed on shaft 15 and connected to said slide valve and valve vane by cam follower rollers 49 and 50.

Provided in the periphery of piston 13 at suitable circumferentially spaced positions around said periphery, are axially aligned radial slots 55 in which are mounted narrow flat seals 56 which are T-head in cross section and thus limited in the distance they are free to extend radially from the periphery of said piston. The function of seals 56 is to maintain the periphery of the piston in snug sealing contact with the bore 12 so as to substantially prevent leakage between the bore 12 and portions of the periphery of the piston 12 closely juxtaposed in relation to said bore wherever the high point 18 of eccentric hub 16 is disposed at its closest spacing with said stator bore. Thus one of the seals 56 is located just clockwise beyond the valve vane 41 when said vane opens as shown in FIG. 2 and remains in sealing engagement with said stator bore until the next successive seal 56 (in a clockwise direction therefrom) comes into sealing relation with said bore as shown in FIG. 3. Seals (not shown) provided in the ends of piston 13 maintain sealing contact with the end plates 14.

OPERATION

To distinguish between the seals 56 in describing the operation of the engine 10, these will be individually identified by adding a different small case letter to the reference numeral 56.

Although not shown on the drawings, it is understood that the engine 10 must be furnished with a carburetor or other source for vaporized fuel in order for it to operate and this is connected to the fuel inlet port 34.

It is also assumed that the engine 10 requires a self starter which is connected to the shaft 15 so as to turn this over in order to start the engine operating. Two or 3 revolutions of this shaft should always be sufficient to start the engine. A complete cycle of the engine 10 is performed with each revolution of shaft 15.

FIG. 1 shows the engine at dead center with the high point 18 of the hub 16 being located at 12 o'clock. The piston 13 is now located in upward tangential contact with the stator bore 12. The slide valve 29 at 12 o'clock has just been closed shutting off the compressed fuel passage 28, and the valve vane 41 at 1:20 o'clock, which has been closed and in sealing engagement with the piston 13 for approximately 180°, is about to be opened by cam 48. FIG. 1 shows the engine in the middle of a fuel suction stroke which is shown as having been completed in FIG. 3. The fuel compression stroke starts with the piston high point 18 at 3 o'clock and concludes with the piston at dead center as shown in FIG. 1. As shown in FIG. 4, the valve vane 41 is allowed to be spring closed by cam 48 while the slide valve 29 is positively cam opened by cam 47 at approximately 6:30 o'clock as shown in FIG. 4. The ignition sub-chamber 44 is thus closed off from the space C–E (combustion exhaust chamber) as shown in FIG. 4 just as this space comes into communication with the exhaust port 33 and starts to contract, thereby expelling exhaust gases from said chamber through said exhaust port. As the high point 18 of hub 16 continues from the point where this is shown in FIG. 4 to its dead center position shown in FIG. 1, the fuel vapor sucked into chamber S–C is compressed and expelled from said chamber through compressed fuel passage 28 and into the ignition sub-chamber 44. It will readily be seen by comparing FIG. 4 and FIG. 1, that during this interval, the compressed fuel thus delivered to sub-chamber 44 is further compressed between the walls of said sub-chamber which include the stator bore 12, the periphery of piston 13, the abutment plunger 25 and the valve vane 41. As shown in FIG. 1, the slide valve 29 is cam closed at approximately 12 o'clock to confine in the ignition sub-chamber 44 the compressed fuel charge delivered thereto, the slide valve 29 remaining thus closed until the conclusion of the power stroke to be effected by the ignition of said charge. Just as that ignition occurs or possibly just before said ignition, the cam 48 functions to open the valve vane 41 so that this is withdrawn radially from engagement with the periphery of the piston 13 as shown in FIG. 2. Seal 56*a* is now already in sealing engagement with the bore 12 at a location close to and on the clockwise side of valve vane 41 as shown in FIG. 2. At this moment, the high point 18 of eccentric hub 16 is about on a radius with the center of combustion chamber 44.

The effect of the expansion of the fuel charge by its ignition in ignition sub-chamber 44 is to apply tangential torque forces to the piston 13 along those portions of the periphery of said piston coming within the compass of seal 56*a* and seal 56*b* as the planetation of said piston advances to the point shown in FIG. 3 where the high point 18 of eccentric hub 16 is at 4:30 o'clock. In fact, seal 56*b* is still in sealing contact with the bore 12 in this view and the expansive pressure of the gases of combustion are still effective in applying tangential torque forces to the piston 13 so long as seal 56*d* remains in sealing engagement with bore 12.

A complete cycle of operation of the engine 10 has now been described. From the phase shown in FIG. 4 with the high point 18 at 6:30 o'clock and just passing over the fuel inlet port 34, a suction stroke is starting which will cause the counter balanced check valve 35 to automatically open and vaporized fuel to be sucked into the suction-compression chamber generated by the travel of the piston 13 between the positions in which this is shown in FIG. 4 to the position in which it is shown in FIG. 5 and in fact, FIGS. 1 and 2.

To facilitate the burning of all pollutants remaining in the gases of combustion produced in each power stroke, the engine 10 is preferably provided with a series of glow plugs or pods 57 which are countersunk in the bore 13 between the valve vane 41 and the exhaust port 33. These plugs are heated by a short running of the engine to an incandescent temperature. While the engine continues to run therefore, the plugs 57 improve combustion and continue to ignite and burn combustible pollutants remaining mixed with the combustion products after the exhaust port opens.

While the engine **10** of the invention is described as preferably having seal vane **32** located at 6 o'clock and exhaust port **33** located at 5:30 o'clock and valve **35** located at 6:30 o'clock, these three elements may as a group be located as much as 30° or more clockwise or counterclockwise from their preferred positions aforesaid. The purpose of such a counter clockwise shift in located would be to shorten the power stroke of the engine and lengthen the suction-compression stroke thereof, and thus invest the engine with a higher compression ratio. A similar clockwise shift would, of course, accomplish the opposite effect.

Engine **10**, although disclosed as preferably operating on vaporized fuel inhaled from a carburetor, is also readily adaptable to be operated as a diesel type engine in which case the air fuel component would be inhaled through valve **35** from the atmosphere and compressed and delivered into sub chamber **44** and the combustible fuel component would be injected directly into the ignition sub chamber **44** by a timed device of the type commonly employed in diesel engine practice.

It is further to be understood that the engine **10** is an adaptation to internal combustion engine practice of the well known Kinney tethered planetating piston pump and that this engine is adapted to employ any of the various types of piston tethering means proven successful in the design of said pumps.

The disclosure of a specific preferred embodiment of the present invention in this application is for illustrative purposes only, the full scope of the invention to be found in the claims construed in the light of the doctrine of mechanical equivalents.

I claim:

1. In a four-phase cycle planetating piston internal combustion engine, the combination of:

a stator having a cylindrical bore closed by end walls providing a pair of bearings co-axial with said bore;

a shaft journalling in said bearings;

an eccentric fixed on said shaft;

a cylindrical annular piston within which said eccentric journals, said piston being co-extensive axially with said bore and of such an outside diameter as to remain in a progressively shifting approximately tangentially sealing contact with said bore as said shaft rotates;

first, second and third abutment means radially biased respectively at about 12 o'clock, 1:20 o'clock and 6 o'clock to seal off the free space between said piston and bore at said respective circumferentially spaced points to produce a fuel vapor suction and compression chamber extending clockwise from 6 to 12 o'clock, a fuel vapor expansion and exhaust chamber extending clockwise from 12 to 6 o'clock, and a fuel charge confinement and ignition sub-chamber extending clockwise between 12 and 1:20 o'clock;

means in said stator providing an exhaust port opening from said bore at an advanced point in said expansion and exhaust chamber;

means in said stator providing a fuel inlet port for admitting gaseous fuel into said suction and compression chamber when the latter is in its suction phase;

first cam controlled passage means delivering compressed gaseous fuel directly from said suction-compression chamber to said ignition sub-chamber, and then shutting said passage means;

second cam controlled means for opening said second abutment means in timely relation with and following the shutting of said passage means;

a timely actuated ignition means for igniting a fuel charge confined by said ignition sub-chamber at the beginning of a power stroke; and

tethering means connected peripherally to said piston to limit the rotation of said piston relative to said stator to a planetating movement in said bore.

2. An engine as recited in claim **1** wherein said stator is provided with a slot extending radially from said bore at 12 o'clock;

said first abutment means slideable in said slot; and

means making a sealed hinged connection between said piston and the inner edge of said first abutment means;

said first cam controlled passage means being embodied in said first abutment means and delivering a compressed fuel charge directly therethrough into said ignition sub-chamber.

3. An engine as recited in claim **2** wherein

at least one of said stator and piston elements is hollowed out in the area of said ignition sub-chamber to provide the compression ratio designed for the engine, and wherein

slots extend radially from the stator bore at 1:20 and at 6 o'clock to slideably receive the second and third abutments which are spring biased from said slots into sealing relation with said piston.

4. In a four-phase cycle planetating piston internal combustion engine, the combination of:

a stator having a cylindrical bore closed by end walls providing a pair of bearings co-axial with said bore;

a shaft journaling in said bearings;

an eccentric fixed on said shaft;

a cylindrical annular piston journalling on said eccentric and being co-extensive with said bore and of such an outside diameter as to remain in tangential sealing contact with said bore as said shaft rotates;

there being a slot in said stator extending radially from said bore at 12 o'clock;

a plunger plate slideable in said slot;

means making a sealed hinged connection between said piston and the inner edge of said plunger plate;

there being a slot in said stator extending radially from said bore at approximately 6 o'clock;

a seal vane radially slideable in said last recited slot and spring biased constantly into sealing relation with the periphery of said piston, said piston plunger and seal vane dividing the vacant space in said stator into a fuel vapor suction and compression chamber extending clockwise from said vane to said plunger, and a combustion and exhaust chamber extending clockwise from said plunger to said vane;

means on said stator providing an exhaust port opening from said bore at about 5:30 o'clock;

means in said stator providing a fuel inlet port for delivering carbureted fuel vapor into said bore at about 6:30 o'clock;

there being a slot in said stator extending radially from said bore at approximately 1:20 o'clock;

a valve vane radially slideably extensible from said last recited slot into sealing relation with said piston;

there being a fuel vapor passage extending through said plunger approximately tangential with said piston;

a compressed-fuel valve controlling said passage;

at least one of said stator and piston elements being hollowed out in the area where they tangentially meet between 12 o'clock and 1:20 o'clock to provide an ignition sub-chamber which, during a power stroke of said engine, comprises an upper portion of said combustion-exhaust chamber;

cam means coordinately actuating said valve vane and compressed fuel valve to close said valve vane while a compressed fuel charge is being delivered through said passage into said ignition sub-chamber, to close said compressed fuel valve at the conclusion of said delivery, to open said valve vane upon the ignition of said fuel charge, to produce a power stroke, to reclose said valve vane at the conclusion of said power stroke and then reopen said compressed fuel valve to admit another compressed fuel charge through said passage into said ignition sub-chamber.

5. An engine as recited in claim **1** wherein said fuel inlet port is provided with a check valve preventing backflow of fuel from said fuel suction compression chamber.

6. An engine as recited in claim **1** wherein the periphery of said piston is provided with radial slots in which narrow flat sealing vanes are trapped so as to be biased to extend radially from said slots a short distance only from the periphery of said piston so that said vane progressively makes sealing engagement co-extensive with the length of said piston with said stator bore so as to impose the main burden of maintaining sealing engagement between said piston and said bore upon said vanes.

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