United States Patent [19]

Brewer

[11] **3,788,286**

[45] **Jan. 29, 1974**

[54] **PISTON ENGINE**

[76] Inventor: **John A. Brewer,** 2120 Kensington Blvd., Fort Wayne, Ind. 46805

[22] Filed: **Apr. 2, 1971**

[21] Appl. No.: **130,685**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 69,006, Sept. 2, 1970, abandoned.

[52] **U.S. Cl.** ..... **123/43 C,** 91/491
[51] **Int. Cl.** **F02b 57/00**
[58] **Field of Search**. 123/43 R, 43 C, 44 E; 91/491, 91/498

[56] **References Cited**

UNITED STATES PATENTS

847,489	3/1907	Millar	123/43 C
1,673,968	6/1928	De Wasmundt	123/43 C X
3,438,358	4/1969	Porsch et al.	123/43 C X
877,977	2/1908	Axtell	123/43 C
1,308,813	7/1919	Shuttleworth	123/43 C
1,324,408	12/1919	Ragot et al.	123/44 E
1,990,660	2/1935	McCann	123/43 C X
2,439,150	4/1948	Smith	123/43 C
3,161,183	12/1964	Leath	123/43 C

FOREIGN PATENTS OR APPLICATIONS

577,663	6/1933	Germany	123/43 C
831,034	2/1952	Germany	123/43 C

Primary Examiner—Allan D. Herrmann
Attorney, Agent, or Firm—Hood, Gust, Irish, Lundy & Coffey

[57] **ABSTRACT**

An internal combustion engine having a rotor member journaled in a casing member for rotation about a first axis. A cylinder is provided on one of the members and has a piston received therein which oscilates between extended and retracted positions. The other of the members is provided with a cam surface having high and low extremities and there are means on the piston forcibly engaging the cam surface, the engaging means in the retracted and extended position engaging the high and low cam surface extremities respectively. The engaging means reacts against the cam surface along a force line laterally off-set from the axis of the rotor member and at generally right angles to a plane therethrough, whereby extension of the piston from its retracted to its extended position causes relative rotation of the rotor member with the engaging means moving over the cam surface from its high towards its low extremity and its point of engagement therewith at all rotational positions between the extremities of the cam surface being on the aforementioned force line.

13 Claims, 16 Drawing Figures

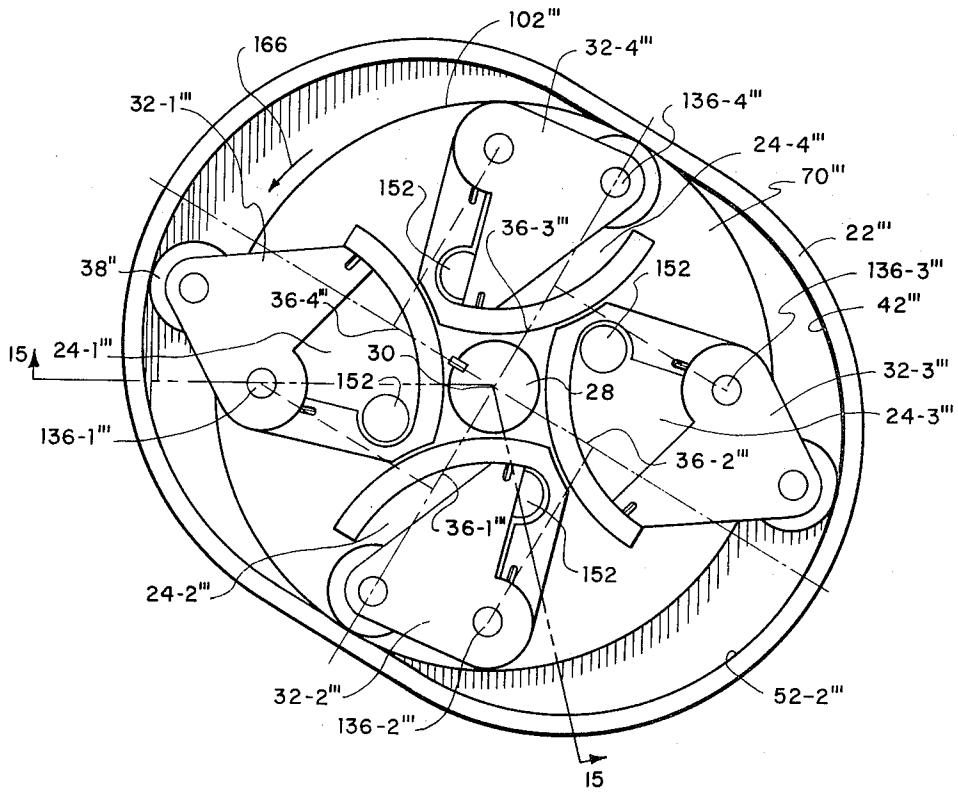
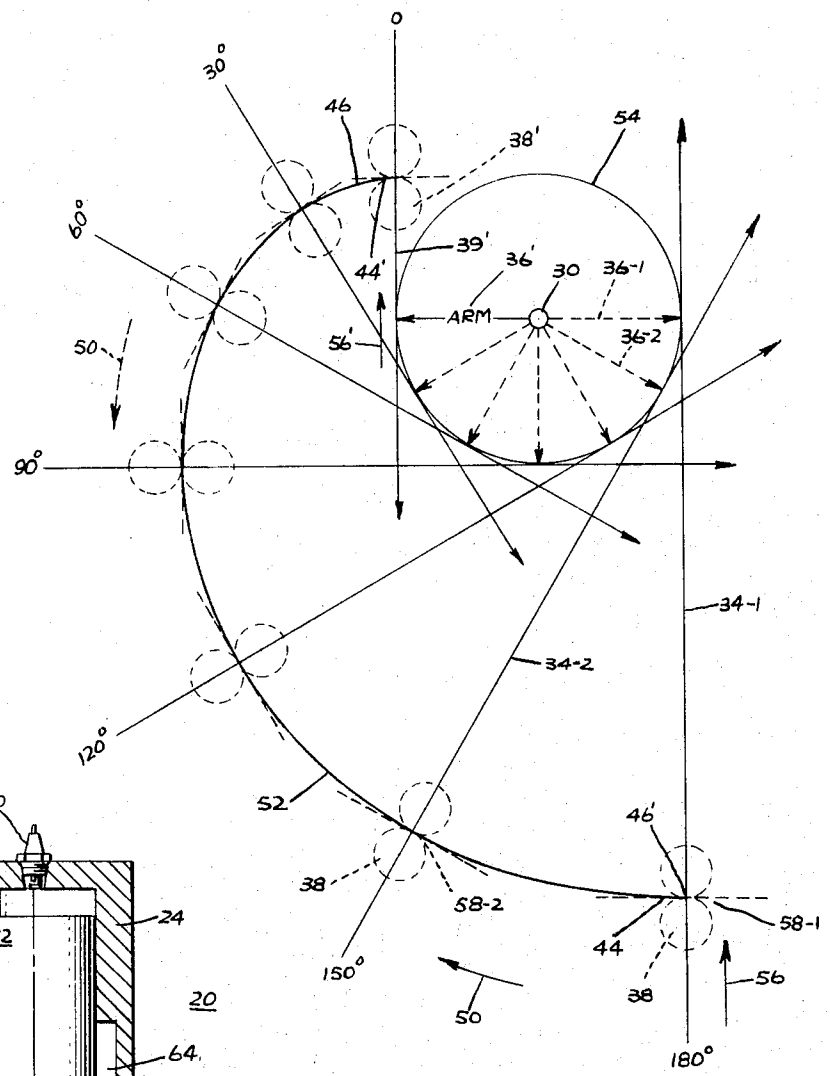


FIG.2



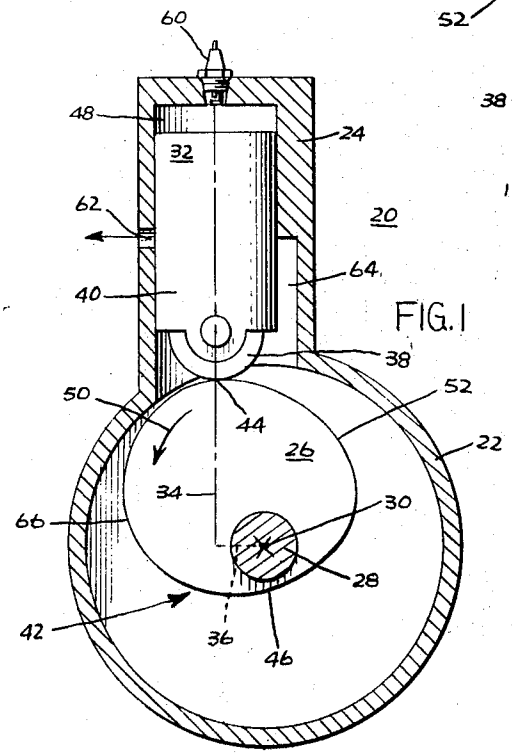


FIG.1

INVENTOR:
JOHN A. BREWER,
BY Hood, Gust, Irish & Lundy
ATTORNEYS

FIG.3

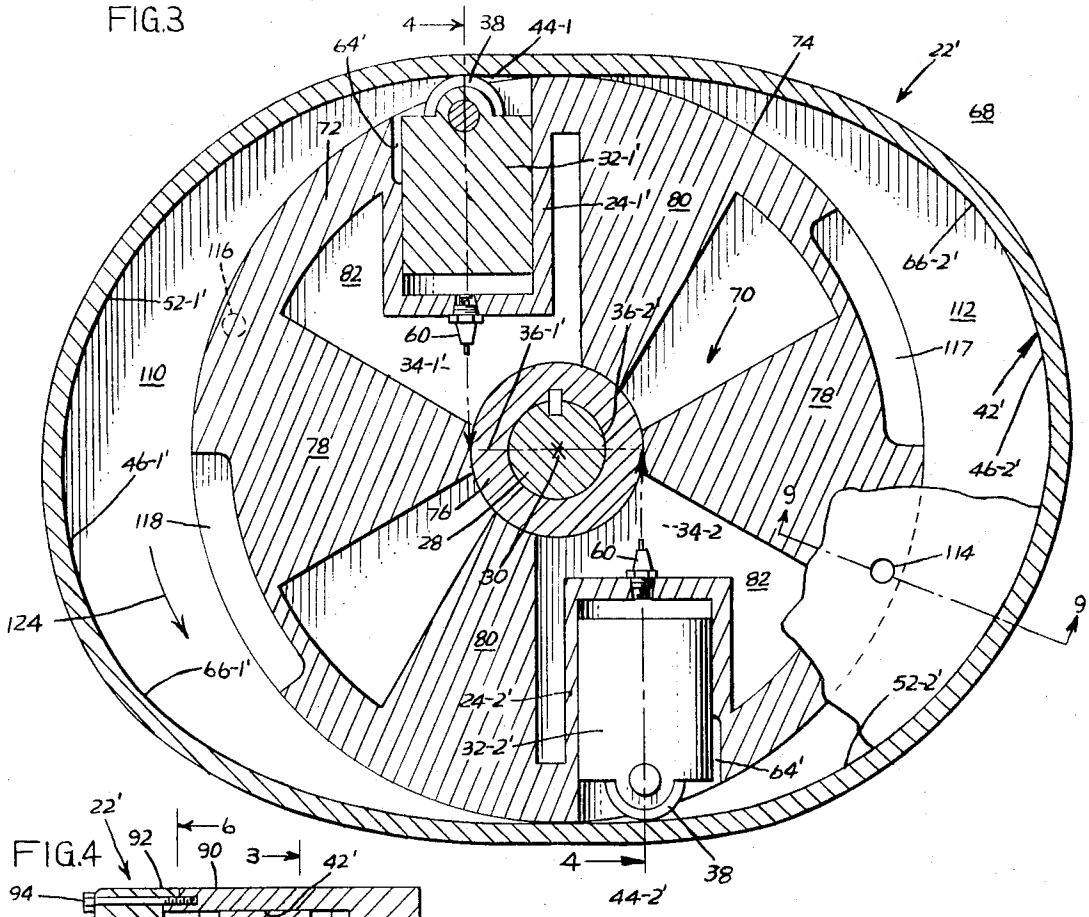
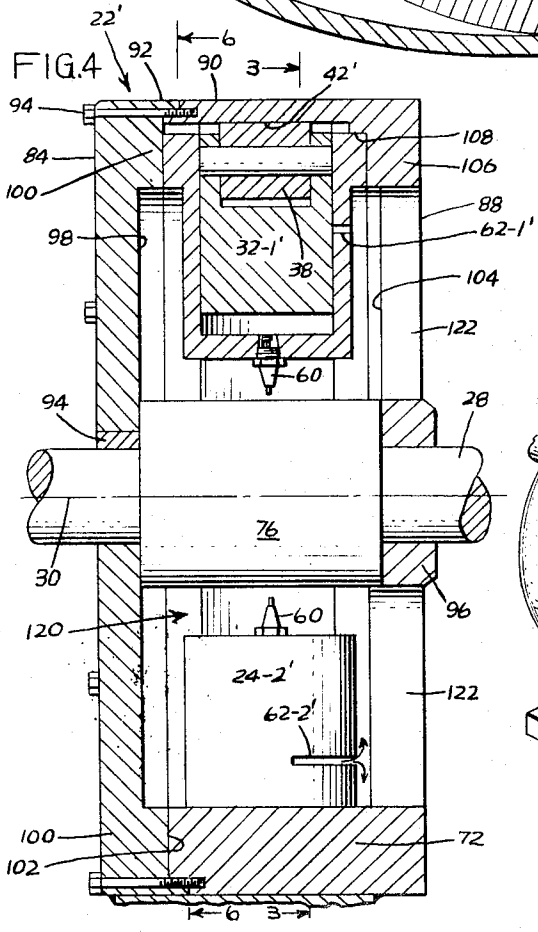


FIG.4



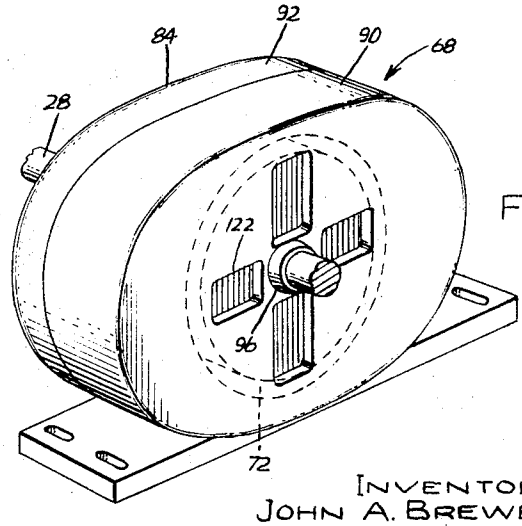
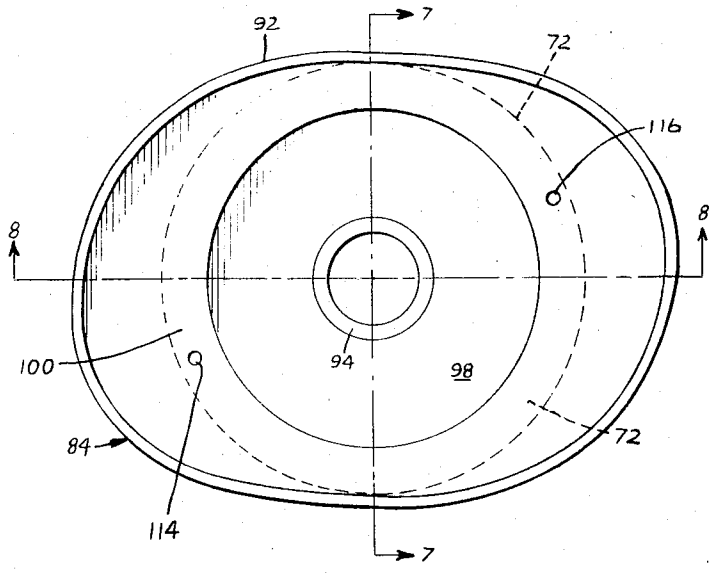


FIG.5

INVENTOR:
JOHN A. BREWER,
BY Wood, Dust, Wright & Lundy
ATTORNEYS.

FIG.6



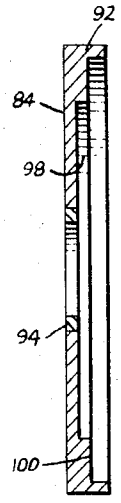


FIG.7

FIG.8

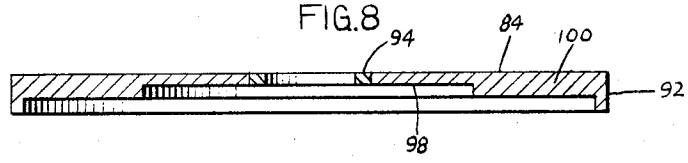


FIG.10

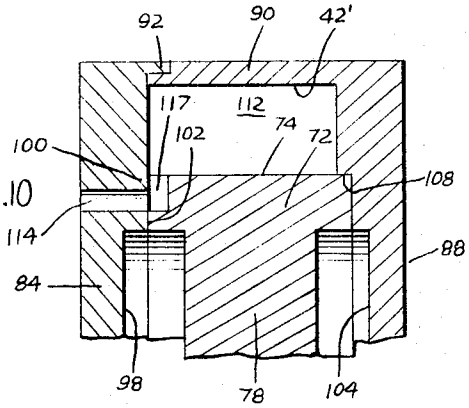
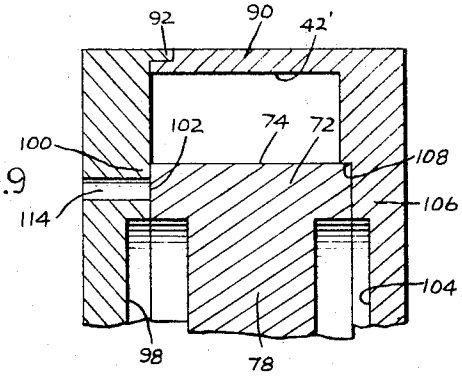


FIG.9



INVENTOR:
JOHN A. BREWER,
BY Head, Gust, Dickinson & Lundy
ATTORNEYS.

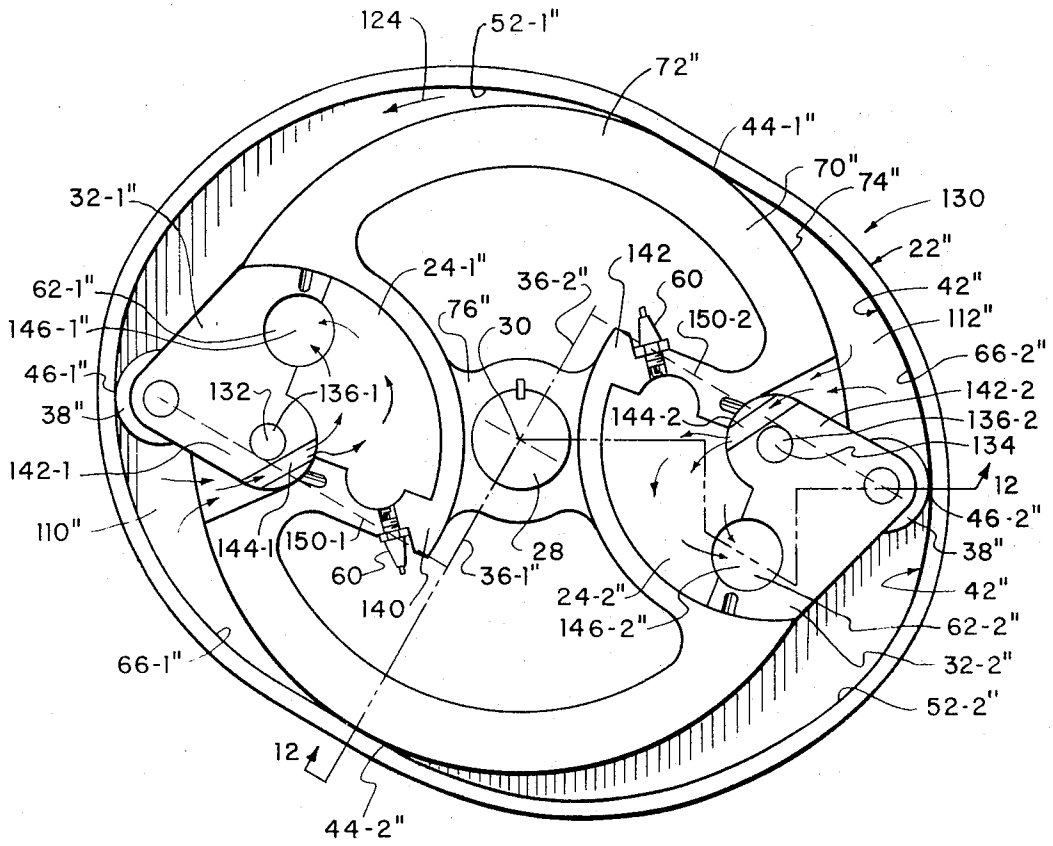


FIG-11

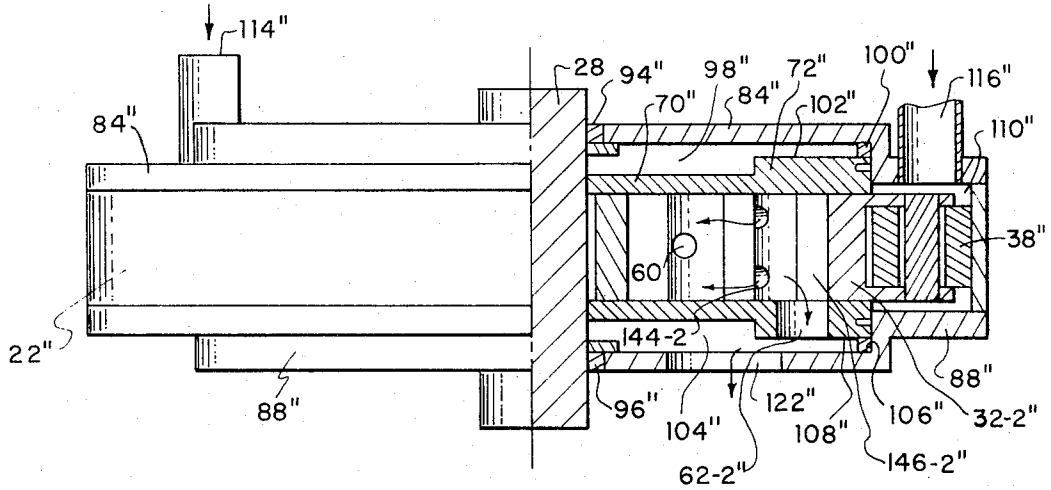


FIG-12

INVENTOR:
JOHN A. BREWER
BY Hood, Gust, Irish, Lundy & Coffey
ATTORNEYS

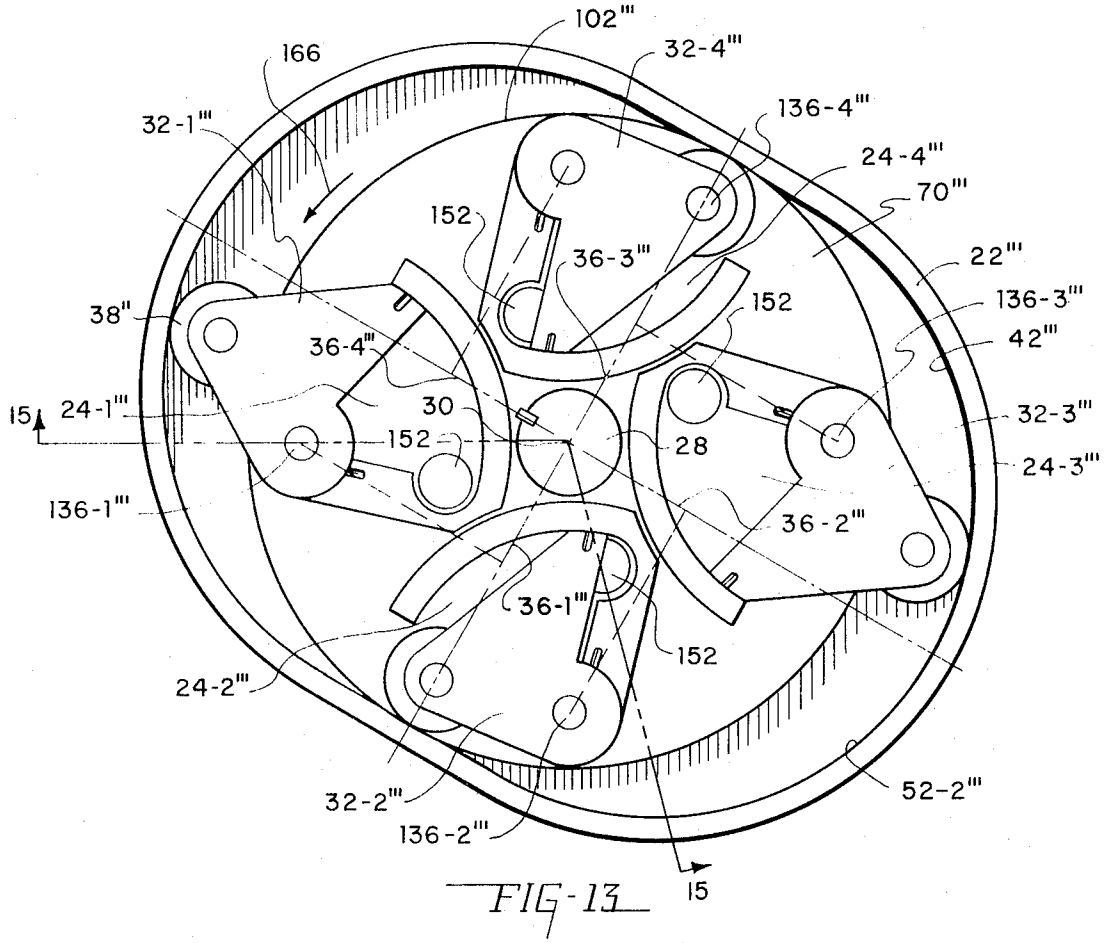


FIG-13

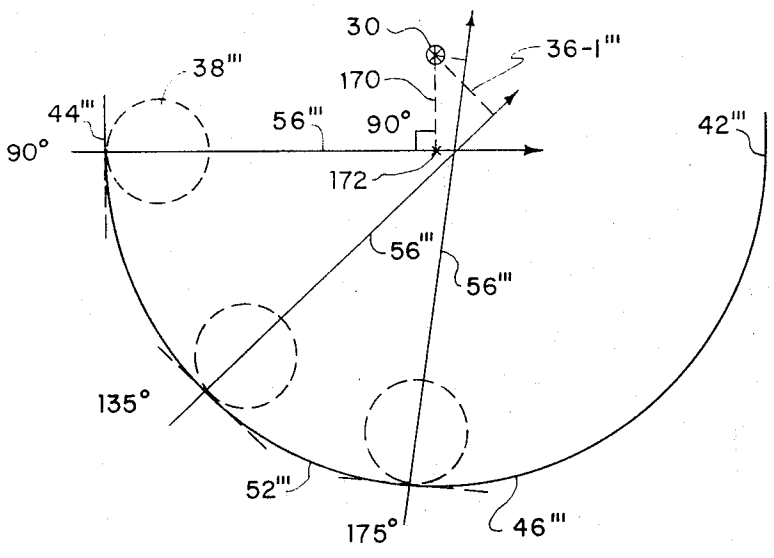


FIG-16

INVENTOR:
JOHN A. BREWER
BY Hood, Hurst, Irish, Lundy & Coffey
ATTORNEYS

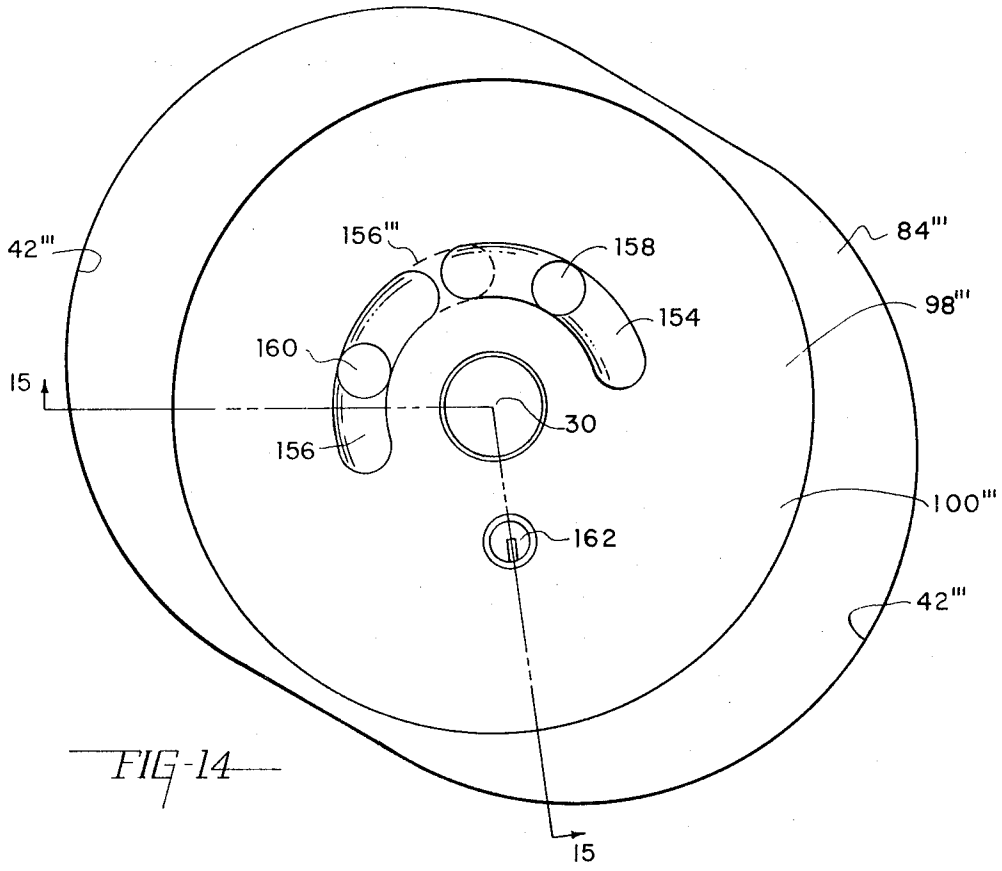


FIG-14

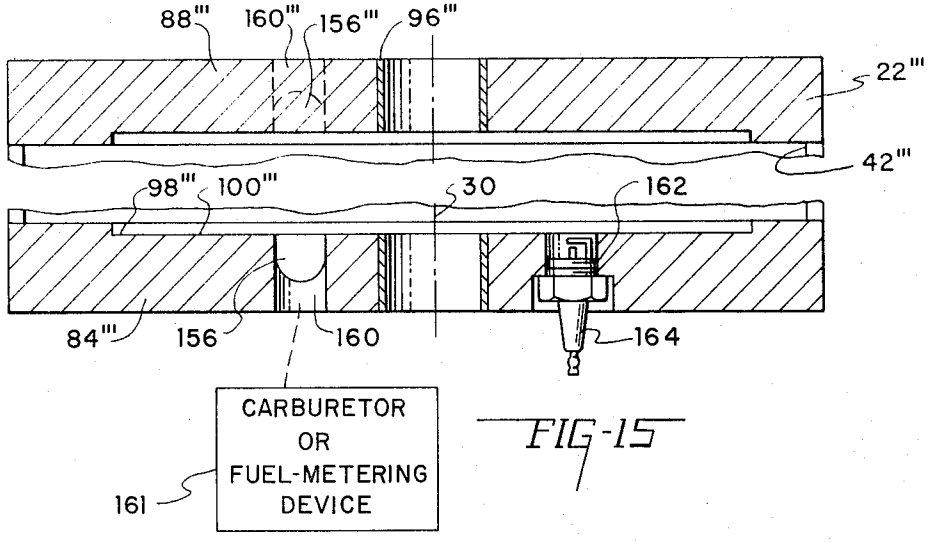


FIG-15

INVENTOR:
JOHN A. BREWER
BY Hood, Hurst, Irish,
Landy & Coffey
ATTORNEYS

PISTON ENGINE

This is a continuation-in-part application of application Ser. No. 69,006, Filed Sept. 2, 1970 and now abandoned.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to piston engines, and more particularly to a piston engine of the type in which a cylinder which is laterally offset from the axis of rotation of the engine has a piston working against a cam surface which is eccentrically disposed with respect to the axis of rotation.

2. Description of the Prior Art

Conventional piston engines comprise a cylinder having a reciprocable piston therein coupled to a crankshaft by a connecting rod. In such conventional piston engines, the power stroke requires substantially 180° rotation of the crankshaft. In the case of a two-cycle internal combustion engine, one power stroke is provided for each revolution of the shaft, and in the case of a four-cycle internal combustion engine, one power stroke is provided for each two revolutions of the shaft. Thus, in such conventional piston engine maximum power is accompanied by relatively high-speed operation. There are instances, however, such as in the case of aircraft engines, where due to propeller characteristics the engine must be operated at a much lower speed, thus sacrificing the power potentially available.

Further, in the case of a conventional piston engine, the length of the crank and thus the radius of the circle traveled thereby must of necessity be one-half the length of the piston stroke. However, due to the vector force relationships during the 180° rotation of the crank between the top and bottom dead-center positions, the effective length of the crank is substantially reduced, i.e., maximum force is developed only at the point during the power stroke of the piston when the crank and connecting rod are disposed at right angles to each other (assuming constant pressure is applied to the piston throughout its power stroke).

It is thus desirable to provide a piston engine capable of developing maximum power at lower R.P.M. compared with a conventional piston engine having the same stroke, displacement and piston pressure. It is further desirable to provide a piston engine in which constant torque is exerted throughout the power stroke. The first objective may be obtained by providing a construction in which two or more power strokes occur during one revolution in the case of two-cycle engine, and at least one power stroke occurs during one revolution in the case of a four-cycle engine. The second objective may be obtained by providing a construction in which the force exerted by the piston, without vector resolution, is at all times at right angles to the crank throughout the power stroke.

U.S. Pat. No. 1,190,660 granted Feb. 12, 1935 to Charles S. McCann discloses a radial internal combustion engine having four radially spaced, outwardly facing cylinders mounted on a rotatable member, each cylinder and its piston therein being disposed on an axis substantially perpendicular to the axis of rotation and laterally spaced therefrom to define a crank arm. Rollers are mounted on the outer ends of the pistons and engage an internal cam surface. The engine of the aforesaid U.S. Pat. No. 1,190,660 provides the above-stated objective of lower engine speed in that each piston has two power strokes during one revolution in the case of a two-cycle engine. However, by reason of the configuration of the cam surface, the engine of the aforesaid U.S. Pat. No. 1,190,660 does not fully accomplish the second objective stated above since the force exerted on the crank arm during the power stroke is still reduced from that available due to vector resolution.

SUMMARY OF THE INVENTION

The invention, it its broader aspects, provides a reciprocating piston machine having a rotor member journaled in a casing member for relative rotation about an axis. A cylinder is provided on one of the members and has a piston received therein which is reciprocable between extended and retracted positions. A cam surface having high and low extremities is provided on the other of the members. There are means on the piston for forcibly engaging the cam surface, the engaging means in the retracted and extended positions of the piston engaging the high and low cam surface extremities, respectively. The engaging means reacts against the cam surface along a force line laterally offset from the axis of the rotor member and at generally right angles to a plane therethrough, whereby extension of the piston from its retracted to its extended position causes relative rotation of the rotor member with the engaging means moving over the can surface from its high towards its low extremity. In specific embodiments, the engaging means at its point of engagement with the cam surface at all rotational positions between the extremities of the cam surface is on the aforementioned force line and on a tangent of the cam surface which is substantially normal to the force line. Thus, when the invention is embodied in an engine, the entire force exerted by the piston by its power stroke, without vector resolution thereof, is exerted at essentially right angles to the axis of the rotor member and at a predetermined crank arm dimension therefrom, thereby increasing the efficiency of the engine over prior piston engines known to the present applicant.

It is accordingly an object of the invention to provide an improved piston engine.

A still further object of the invention is to provide an improved piston engine of the type wherein the piston or pistons work agaist a cam surface.

The above-mentioned and other features and objects of this invention and the manner of attaining them will become more apparent and the invention itself will be best understood by reference to the following description of an embodiment of the invention taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view showing a single cylinder, two-cycle internal combustion engine incorporating the invention;

FIG. 2 is a diagram showing the involute curvature of the cam of the engine of FIG. 1 useful in explaining the invention;

FIG. 3 is a cross-sectional view showing a two cylinder, two-cycle internal combustion engine incorporating the invention;

FIG. 4 is a cross-sectional view taken generally along the line 4—4 of FIG. 3;

FIG. 5 is a view in perspective showing one end of the engine of FIGS. 3 and 4;

FIG. 6 is an end view of one of the end walls of the casing of the embodiment of FIGS. 3–5, viewed generally along the line 6—6 of FIG. 4;

FIG. 7 is a cross-sectional view taken generally along the line 7—7 of FIG. 6;

FIG. 8 is a cross-sectional view taken generally along the line 8—8 of FIG. 6;

FIG. 9 is a fragmentary cross-sectional view taken along the line 9—9 of FIG. 3 and showing the air-fuel intake port closed;

FIG. 10 is a fragmentary cross-sectional view similar to FIG. 9 but showing the rotor member rotated such that the air-fuel intake port is open;

FIG. 11 is a cross-sectional view showing an alternative embodiment of this invention in the form of a modified two cylinder, two-cycle internal combustion engine incorporating the invention;

FIG. 12 is a fragmentary cross-sectional view taken generally along the line 12—12 of FIG. 11;

FIG. 13 is a cross-sectional view of still another embodiment showing a four-cylinder, four-cycle internal combustion engine in accordance with the invention;

FIG. 14 is an end view of one of the end walls of the casing of the embodiment of FIG. 13;

FIG. 15 is a fragmentary cross-sectional view taken along the line 15—15 of FIG. 13 and showing the intake-exhaust port in the intake position; and

FIG. 16 is a diagram showing the curvature of the modified cam surface used in the embodiment of FIG. 13 useful in explaining the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1 of the drawings, there is shown at 20 a single cylinder, two-cycle internal combustion engine having a casing 22 with cylinder 24 extending outwardly therefrom. Cam 26 is provided in casing 22 and is secured to output shaft 28 for rotation therewith, shaft 28 being suitably journaled in casing 22 for rotation about axis 30.

Cylinder 24 has piston 32 reciprocably received therein, piston 32 being coaxial with axis 34 which is substantially normal to a plane including axis 30 and which is laterally offset therefrom by crank arm dimension 36, axis 34 of piston 32 thus being substantially at a right angle with respect to crank arm dimension 36. Piston 32 has a roller 38 rotatably mounted on its lower end 40, roller 38 operatively engaging outer surface 42 of cam 26. Cam 26 has a high extremity 44 and a low extremity 46. Piston 32 is reciprocable in cylinder 24 on axis 34 between a retracted position with roller 38 engaging high extremity 44 of cam 26, as shown in FIG. 1, and an extended position with roller 38 engaging low extremity 46. It will readily be seen that extension or movement of piston 32, from its retracted position to its extended position as shown by arrow 56, in response to pressure in cylinder head cavity 48 will result in the application of force on axis 34 at a right angle to crank arm dimension 36, resulting in rotation of cam 26 and shaft 28 in the direction shown by the arrow 50.

Referring additionally to FIG. 2 of the drawing, portion 52 of surface 42 of cam 26 extending between high and low extremities 44, 46 is formed as substantially an involute curve generated about a circle 54 coaxial with axis 30 and having the crank arm dimension 36 as its radius. Considering the engine of FIG. 1 wherein the involute surface 52 is exteriorly formed on cam 26 and piston 32 exerts force inwardly toward cam 26 in the direction shown by arrow 56, and assuming that cam 26 is held stationary and casing 22 and cylinder 24 rotate about axis 30, it will be observed that with roller 38 initially engaging high extremity 44, piston 32 will be exerting force in direction 56 along its axis 34–1 on crank arm 36–1 at substantially a right angle thereto, and that the point of engagement of roller 38 with high extremity 44 of involute curve 52 is on axis 34–1 and on a tangent of involute curve 52 which is at a right angle to axis 34–1, as shown by the dashed line 58–1. Thus, all of the linear force exerted by extension of piston 32 is applied, without reduction by vector resolution, to crank arm dimension 36–1 and at a right angle thereto. With cam 26 considered to be stationary and casing 22 and cylinder 24 rotating with respect thereto, this application of extensive force by piston 32 will result in rotation of casing 22 and cylinder 24 about axis 30 as shown by the arrow 50 in FIG. 1. With casing 22 and cylinder 24 stationary and cam 26 rotatable, as shown in FIG. 1, extension of piston 32 will rotate cam 26 in the opposite direction 50'.

Considering now that the extensive force exerted by piston 32 has resulted in a 30° rotation of casing 22, cylinder 24, piston 32 and roller 38, it will be seen that piston 32 is now exerting force along its axis 34–2 which is applied at a right angle to crank arm dimension 36–2, roller 38 still engaging involute curve 52 at a point on axis 34–2 and on a tangent thereto, as shown by the dashed line 58–2, which is at a right angle to axis 34–2. Thus, all of the linear force exerted due to the extension of piston 32 is again applied to crank arm dimension 36–2 at a right angle thereto without reduction due to vector resolution of the force.

Further inspection of FIG. 2 will reveal that by reason of the involute curvature of cam surface portion 52 between the high and low extremities 44, 46, the point of engagement of roller 38 with involute curve 52 at all rotational positions between the high and low extremities is on axis 34 of piston 32 and on a tangent 58 of involute 52 which is at a right angle to axis 34, axis 34 also at all rotational positions applying force on crank arm dimension 36 at a right angle thereto. Thus, all of the linear force exerted by piston 32 during its extension or power stroke is directly applied at a right angle to the crank arm dimension or effective crank arm 36 which has the same effective length at all rotational positions thereof. It will now be seen that maximum torque is applied at all rotational positions between the high and low extremities of the cam in contrast with prior piston engines in which the torque varies during rotation due to vector resolution of the applied force and/or variation in the effective length of the crank.

It will further be seen that if cam surface 52 between the high and low extremities 44, 46 has a curvature other than one closely approaching an involute, the point of engagement of roller 38 with the cam surface will not, at all rotational positons, be on the axis 34 of piston 32 and on a tangent of the cam surface which is substantially at a right angle to the piston axis, and therefore that the force applied on the crank arm 36 will be reduced from that applied by extension of piston 32 by the requisite vector resolution.

Referring still to FIG. 2, it will be seen that the involute cam surface 52 may be interiorly formed on casing 22 and the cylinder mounted on the rotatable member with its piston and roller 38' exerting force outwardly

on the interior involute cam surface 52. In this case, extremity 44' is the high extremity and extremity 46' is the low extremity. Here again, axis 34' of cylinder 24 and piston 32 is at a right angle with respect to axis 30 of the rotatable member which carries the cylinder and piston, and laterally offset therefrom by crank arm dimension 36'. Assuming again that the member which mounts cylinder 24 and piston 32 is stationary and that the casing 22 having cam surface 52 thereon is rotatable with respect thereto about axis 30, extension of piston 32 and roller 38' in the direction shown by the arrow 56' will cause rotation of casing 22 and involute cam surface 52 in the direction shown by the arrow 50', the point of engagement of roller 38' with involute cam surface 52 at all rotational positions between the high and low extremities 44', 46' again being on axis 34' and on a tangent 58 of involute curve 52 which is at a right angle with respect to axis 34'.

Returning briefly to FIG. 1, cylinder 24 of engine 20 will be provided with a conventional spark plug 60, a conventional exhaust port 62 and a conventional air-fuel mixture inlet port 64, as in the case of any other conventional two-cycle internal combustion engine. The portion 66 of cam surface 42 extending between high and low extremities 44, 46 and diametrically opposite the involute surface 52 may have any desired configuration for returning piston 32 from its extended to its retracted position. It will be readily apparent that engine 20 may be a four-cycle engine employing conventional intake and exhaust valves actuated in proper sequence by a conventional cam shaft as is well known to those skilled in the art.

Referring now to FIGS. 3 through 10 of the drawings in which like elements are indicated by like reference numerals and similar elements by primed reference numerals, a two cylinder, two-cycle internal combustion engine 68 is shown in which cam surface 42' is interiorly formed on casing 22', cylinders 24–1' and 24–2' being carried by rotor member 70 mounted on shaft 28, with pistons 32–1' and 32–2' exerting force outwardly on cam surface 42'.

Here, cam surface 42' has two diametrically opposite high extremities 44–1' and 44–2', and two diametrically opposite low extremities 46–1' and 46–2'. Axes 34–1' and 34–2' of pistons 32–1' and 32–2', respectively, are both normal to the same plane including axis 30 of shaft 28, and are respectively laterally offset on opposite sides thereof by equal crank arm dimensions 36–1', and 36–2'. Diametrically opposite portions 52–1', and 52–2' of cam surface 42' respectively, extending between high and low extremities 44–1', 46–1' and 44–2' and 46–2' are again involute curves formed about a circle having crank arm dimensions 36–1' and 36–2' as its radius, as explained above in connection with FIG. 2. Cam surface portions 66–1' and 66–2', respectively, extending between involute cam surface portions 52–2' and 52–2' may also have an involute curvature, or may have any other curvature suitable for respectively returning pistons 32–1' and 32–2' from their extended to their retracted positions.

Rotor member 70 comprises an outer, annular rim portion 72 having a cylindrical outer surface 74. Rim portion 72 is supported on hub portion 76 by radially spaced spokes 78 and 80. Cylinders 24–1' and 24–2' are recessed in rotor member 70, extending inwardly from cylindrical surface 74 into spaces 82 between spikes 78 and 80, as shown. Cylindrical surface 74 of rotor member 70 is in sliding engagement with high extremities 44–1' and 44–2' of internal cam surface 42'.

Casing 22' includes a first end wall 84 and a second end wall 88 having an outer flange portion 90 secured to a mating flange portion 92 of end wall 84 in any suitable manner, as by threaded fasteners 94. Internal cam surface 42' is formed on the interior of flange portion 90 of end wall 88. End walls 84, 88, respectively, carry suitable bearings 94, 96 which rotatably support shaft 28.

End wall 84 has an annular recess 90 formed therein which defines an outer bearing area 100 in sliding engagement with side 102 of rim 72 of rotor member 70. End wall 88 has a similar annular recess 104 formed therein defining an outer bearing area 106 in sliding engagement with side 108 of rim 72. By reason of the sliding engagement of sides 102, 108 of rim 72 with bearing areas 100, 106 of end walls 84, 88, respectively, and the sliding engagement of outer cylindrical surface 74 of rotor member 70 with the high extremities 44–1' and 44–2' of cam surface 42', a pair of diametrically opposite cavities 110, 112 are defined between outer cylindrical surface 74 and cam surface 42'. Cylinders 24–1' and 24–2' each have an air-fuel mixture intake port 64' formed therein communicating with cavities 110, 112.

In order to admit the air-fuel mixture to cavities 110, 112, and thence to cylinders 24–1' and 24–2' through ports 64', a pair of air-fuel inlet openings 114, 116 are formed in end wall 84 extending from the outer surface thereof to the outer bearing area 100 thereof and thus being in general alignment with rim 72 of rotor member 70. Side surface 102 of rim 72 (FIG. 10) which is in sliding engagement with outer bearing area 100 has a pair of diametrically opposite recesses 117, 118 formed therein, recesses 117, 118 communicating with cavities 110, 112 and being bounded on one side by outer bearing area 100 of end wall 84.

Reference to FIGS. 3 and 9 will reveal that in the illustrated position of rotor member 74, side surface 102 of rim 72 blocks air-fuel mixture intake openings 114, 116. However, as rotor member 70 is rotated, recesses 117, 118 come into alignment with air-fuel mixture inlet openings 114, 116, thereby admitting the air-fuel mixture to cavities 110, 112 and thence through intake ports 64' to cylinders 24–1' and 24–2'. It will be understood that recesses 117, 119 are so located and have the proper radial extent so as to admit the air-fuel mixture to the cylinders during the proper time in a complete cycle of operation.

It will be seen that annular recesses 98 and 104 in end walls 84, 88 define a central cavity 120 (FIG. 4) within outer bearing areas 100,106 and rim 72. Cylinders 24–1' and 24–2' are provided with exhaust ports 62–1' and 62–2' which communicate with cavity 120. End wall 88 has a plurality of exhaust openings 122 formed therein communicating with inner cavity 120 for exhausting spent gases from the engine.

Referring specifically to FIG. 3, it will be observed that as pistons 32–1' and 32–2' extend, forces are exerted along their respective axes 34–1' and 34–2' at right angles to crank arms 36–1' and 36–2', thus causing rotor member 70 and shaft 28 to rotate about axis 30 in the direction shown by arrow 124. Assume now that rotor member 74 is in the position shown in FIG. 3 with both pistons 32–1', 32–2' at the top of their strokes, i.e., just beginning the power stroke so as to cause rotor member 74 to rotate in direction 124. As

cylinders 24–1′, 23–2′ rotate, pistons 32–1′, 32–2′ extend sufficiently to open exhaust ports 62–1′, 62–2′, thereby permitting the exhaust gases to flow outwardly through the exhaust ports into cavity 120 and thence through exhaust openings 122. As the cylinders continue to rotate in direction 124, recesses 118, 117 (FIG. 3) respectively, come into alignment with air-fuel inlet openings 114, 116, thus permitting the air-fuel mixture to flow into cavities 110, 112 (FIG. 3), and thence through inlet ports 64′ opened by the extension of pistons 32–1′, 32–2′. As in conventional two-cycle engines, the outward rush of exhaust gas from the cylinders through 62–2′ creates a partial vacuum which draws the air-fuel mixture through ports 64′ into the cylinder.

As rotation of rotor member 74 continues in direction 124, rollers 38 move past low cam points 46–1′, 46–2′ and return of the pistons toward the top of their strokes commences. As rotation further continues, inward movement of the pistons closes inlet ports 64′ and recesses 118, 117 move out of alignment with openings 114, 116. The pistons close the exhaust ports and the compression cycle continues until the rollers again reach high cam points 44–1′, 44–2′, as shown in FIG. 3, at which point another power stroke commences. It will be seen that for each cylinder, one less bearing is required, i.e., in a conventional piston engine bearings are required at each end of the connecting rod whereas, the engine of this invention only requires one bearing for the piston roller.

Referring now to FIGS. 11 through 14 of the drawings, in which like elements are again indicated by like reference numerals and similar elements by double primed reference numerals, a two cylinder, two-cycle internal combustion engine 130 is shown in which cam surface 42″ is interiorly formed on casing 22″. In this embodiment, the cylinders 24–1″ and 24–2″ are in the shape of sectoral portions of cylinders having their axes at 132 and 134, respectively. Pistons 32–1″ and 32–2″ are received within cylinders 24–1″, 24–2″ and pivotally secured to rotor 70″ with pivot pins 136–1, 136–2 which extend through the rotor 70″ and pistons 31–1″, 32–2″ coaxially of axes 132 and 134, respectively. Pistons 32–1″, 32–2″ are provided with rollers 38″ which provide a means on the pistons 32–1″, 32–2″ for engaging cam surface 42″, whereby, as the pistons 32–1″, 32–2″ pivot about axes 132, 134, respectively, they will exert a force outwardly against cam surface 42″.

As in the engine of FIG. 3, cam surface 42″ has two diametrically opposite high extremities 44–1″ and 44–2″, and two diametrically opposite low extremities 46–1″ and 46–2″. Diametrically opposite portions 52–1″ and 52–2″ of cam surface 42″ respectively extending between high and low extremities 44–1″, 46–1″ and 44–2″ and 46–2″ are again involute curves formed about a circle having crank arm dimensions 36–1″ or 36–2″ as its radius, as explained above with reference to FIG. 2. Cam surface portions 66–1″ and 66–2″, respectively, may also have an involute curvature, or may have any other curvature suitable for smoothly returning pistons 32–1″ and 32–2″ from their extended to their retracted positions.

Rotor member 70″ comprises an outer, annular rim portion 72″ having a cylindrical outer surface 74″. Cylinder walls 140 and 142 also serve as spokes which support rim portion 72″ on hub portion 76″. Cylindrical surface 74″ of rotor member 70″ is in sliding engagement with high extremities 44–1″ and 44–2″ of internal cam surface 42″.

Pistons 32–1″ and 32–2″ are provided with hub portions 142–1 and 142–2, respectively concentric with axes 132, 134. Ports 144–1 and 144–2 are formed through hub portions 142–1, 142–2 along a chord of the hub portions thereof at an angular relationship to pistons 32–1″ and 32–2″ wherein they communicate between the interiors of the cylinders 24–1″, 24–2″ and cavities 110″, 112″ when pistons 32–1″ and 32–2″ are adjacent their extended positions as shown. Cavities 110″ and 112″ are, as explained above in reference to the embodiment illustrated in FIG. 3, defined between outer cylindrical surface 74″ and cam surface 22″.

Pistons 32–1″ and 32–2″ have recesses 146–1″146–and 145–2″ formed in the pressure surfaces thereof, and cylinders 24–1″ and 24–2″ are provided with exhaust ports, 62–1″ and 62–2″ which are formed through the end walls of rotor 70″ and communicate with the interior of cylinders 24–1″ and 24–2″ as shown.

The casing includes first and second end walls 84″ and 88″ which carry suitable bearings 94″, 96″ which rotatably support shaft 28, which is keyed to rotor 70″ for rotation therewith.

As in the embodiment described in FIG. 3, end wall 84″ has annular recess 98 formed therein which defines an outer bearing area 100″ in sliding engagement with side 102″ of rim 72″ of rotor member 70″. End wall 88″ has a similar annular recess 104″ formed therein defining an outer bearing area 106″ in sliding engagement with side 108″ of rim 72″.

To admit the air-fuel mixture to cavities 110″, 112″, and thence to cylinders 24–1″ and 24–2″ through ports 144–1, 144–2, a pair of air-fuel inlet openings 114″, 116″ are formed in end wall 84″ extending from the outer surface thereof to cavities 110″, 112″.

A plurality of openings 122″ are formed through end wall 88″ communicating with cylindrical recess 104″ and exhaust ports 146–1″, 146–2″ for exhausting spent gases from the engine.

It will be observed that when the engine 130 is operating, pistons 32–1″, 32–2″ will move downwardly within cylinders 24–1″, 24–2″, respectively. As pistons 32–1″, 32–2″ approach the downward limit of their motion, exhaust ports 62–1″, 62–2″ will begin to open and spent gases will begin exhausting therethrough. As pistons 32–1″, 32–2″ move further downwardly, hub portions 142–1, 142–2 of the pistons will rotate sufficiently to open intake ports 144–1, 144–2 and the momentum of exhaust gases being exhausted through exhaust ports 142–1, 142–2 will cause fresh air-fuel mixture to be drawn inwardly through intake ports 144–1, 142–2. As rotor 70″ continues to rotate, pistons 32–1″, 32–2″ will move upwardly in cylinders 24–1″, 24–2″ compressing the air-fuel mixture in conventional manner. When pistons 32–1″, 32–2″ approach the upward limit of their motion the air-fuel mixture will be ignited by spark plugs 60 forcibly driving pistons 32–1″, 32–2″ downwardly in cylinders 24–1″, 24–2″, forcibly rotating rotor 70″.

It will be observed that as pistons 32–1″ and 32–2″ extend, forces are exerted via rollers 38″ against cam surface portions 52–1″ and 52–2″. Because the cam surface portions 52–1″ and 52–2″ are formed in an in-

volute curve as above-described, the reactive force against rollers 38'' rotatably drives rotor 70'' along force lines perpendicular to the tangent of the cam surface at the point of contact of roller 38'' therewith via pins 136–1 and 136–2. It is thus seen that this reactive force is exerted along lines 150–1 and 150–2 at right angles to crank arms 36–1'' and 36–2'', thus causing rotor member 70'' and shaft 28 to rotate about axis 30 in the direction shown by arrow 124.

It will be observed that in the embodiments illustrated in FIGS. 3 and 11, each piston will complete one complete cycle of operation, i.e., power-exhaust and intake-compression, for each 180° of rotation of rotor member 70 or 70'', and that each cylinder completes two complete cycles of operation during each complete 360° of rotation of rotor member 80 or 70''. Thus, full power operation is provided at one-half the rotational speed of a conventional two-cycle engine. While the engines 68 of FIGS. 3 through 10, and 130, of FIG. 11 are shown as being of the two-cycle type, it will be readily apparent that a four-cycle engine may be provided with the provision of suitable intake and exhaust valves. For example, an embodiment of the engine of FIG. 11 suitably modified for four-cycle operation is illustrated in FIGS. 13 and 15.

In this embodiment, which again uses an internally formed cam surface 42''', rotor 70''' is provided with four cylinders 24–1''', 24–2''', 24–3''', and 24–4''' orthogonally arranged in diametrically opposite pairs, and is keyed to shaft 28.

Each of cylinders 24–1''' through 24–4''' is provided with a respective inlet-exhaust port or passage 152 extending through the wall thereof as shown. End wall 84''' (FIG. 14) of casing 22''', has an annular recess 98''' formed therein, an outer wall-like bearing area 100''' that slidingly engages a side of rotor 70''', and a pair of arcuate grooves or recesses 154 and 156 therein coaxial with respect to axis 30 and having a radial displacement from axis 30 equal to the radial displacement of inlet-exhaust ports 152 in cylinders 24–1''' through 24–4'''. The angular length of the grooves 154, 156 equals the degrees of rotation required for the exhaust and intake strokes of the pistons, respectively, and are angularly positioned with respect to cam surface 42''' such that recess 154 is registered with inlet-exhaust ports 152 of cylinders 24–1''' through 24–4''' in sequence, as each of the pistons 32–1''' through 32–4''' therein is moving inwardly in its respective cylinder. Similarly, ports 152 of the respective cylinders 24–1''' through 24–4''' are registered with recess 156 in sequence during that portion of the rotation of rotor 70''' when the pistons are moving downwardly or outwardly of the cylinders 24–1''' through 24–4''' immediately following the exhaust stroke thereof. During the remainder of the rotational movement of the rotor it can be seen that inlet-exhaust ports 152 of the respective cylinders are closed by the wall portion 100''' of end plate 84'''. Recesses 154 and 156 are further provided with apertures 158, 160 respectively, which extend outwardly through end plate 84''' in a direction parallel to the axis 30. A suitable fuel-air mixing device 162, such as a conventional carburator or fuel injection system, is connected to aperture 160 while aperture 158 communicates with the atmosphere and provides a means for exhausting spent gases from the cylinders.

End wall 88''' comprises a simple flat plate and is fitted with a suitable bearing 96''' for rotatably carrying shaft 76. Alternately, one of arcuate recesses 154 or 156 may be formed in end plate 88''' as indicated by dotted lines 156''' whereby the intake and exhaust recesses 156''' and 154 can have some overlap to increase efficiency of the engine at higher operating speeds. Of course, if arcuate recesses 156'''or 154 are formed in opposite ones of end plates 84''', 88''', it will be necessary to form a second inlet-exhaust port 152''' in the oppositely disposed side wall of cylinders 36–1''' through 36–4'''.

A threaded hole 162 is provided in end plate 84''' parallel to axis 30, this hole again having a radial displacement from axis 30 equal to the radial displacement of inlet-exhaust ports 152 of cylinders 24–1''' through 24–4''' and a conventional spark plug 164 is fitted therein. The rotational position of hole 162 is such that the respective inlet-exhaust ports 152 of cylinders 24–1''' through 24–4''' are sequentially in alignment with hole 162 and spark plug 164 when respective ones of pistons 32–1''' and 32–4''' are adjacent the inward limit of their stroke following an intake of air-fuel mixture via aperture 160 and recess 156. Thus, it is apparent that this single spark plug 164 is, in sequence, properly positioned relative to cylinders 24–1''' – 24–4''' to provide ignition therefor.

In tracing the operation of piston 32–4''' during one complete revolution of rotor member 70''' starting with piston 32–4''' in the position as shown in FIG. 13 with rotor member 70''' moving in the direction indicated by arrow 166 the following sequence of events is observed. Port 152 is in alignment with arcuate recess 156 adjacent one end thereof. As rotor 70''' rotates, piston 32–4''' moves downwardly (outwardly) away from port 152 drawing air-fuel mixture into cylinder 24–4''' via arcuate recess 156 and inlet aperture 160. When rotor 70''' rotates approximately 90°, port 152 is sealed by end plate 84'''. As rotor member 70''' continues to rotate, piston 32–4''' moves inwardly in cylinder 24–4''' compressing the air-fuel mixture therein, and, when piston 32–4''' is adjacent the inward limit of its motion, port 152 comes into registry with hole 162 and spark plug 164. At this point, spark plug 164 is fired igniting the air fuel mixture in cylinder 24–4''', driving piston 32–4''' downwardly. Piston 32–4''' exerts an outward force against cam surface 52–2''' generating a rotational moment on rotor member 70'''. When piston 32–4''' reaches the lower limit of its movement, port 152 comes into alignment with arcuate recess 154, and, as piston 32–4''' begins to move upwardly in the cylinder 24–4''', it forces spent exhaust gases outwardly therefrom via arcuate recess 154 and aperture 158. It is thus seen that this embodiment provides proper timing for four cycle operation and does so with a minimum of complexity, and in particular, does so without requiring the use of any additional moving parts in the engine.

While an interior cam surface on the casing member is employed with the cylinders being mounted on the rotor member in the embodiments of FIGS. 3 – 14, it will be readily understood that the cam surface may be exteriorly formed on the rotor member and the cylinders mounted on the casing, as shown in the embodiment of FIG. 1.

In the embodiment of the engine of the present invention shown in FIGS. 11 and 12, cam surface 42'''

has been described as including involute curve portions 51–1''' and 52–2'''. However, it will be apparent that due to the vector resolution of the forces developed by the piston and the essentially frictionless characteristic of the cam-engaging rollers 38 thereof, these engines will develop a rotational moment for driving rotor member 70 about axis 30 with a wide variety of smooth curve cam surface configurations. For example, referring to FIG. 16, portion 52''' of surface 42''' extending between high and low extremities 44''', 46''' is formed as substantially a circle having its axis 30 off-set from center 172 by a predetermined dimension 170. With roller 38''' initially engaging high extremity 44''' pistons 32–1''' through 32–4''' will exert force in a direction 56''' which is perpendicular to a tangent of surface 42'''. This force will always be perpendicular to a tangent of surface 42''' by reason of the essentially frictionless character of roller 38''' which prevents components of force parallel to tangents of surface 42''' from being transmitted therethrough. As roller 38''' continues to move along cam surface 42''', it will exert a force in direction of 56''' which acts at a right angle to crank arm 36–1''' through 36–4''', respectively. It is noted, however, that the length of the crank arm dimension does not remain constant in this embodiment, but rather, has a maximum dimension when roller 38''' is in contact with the high cam surface extremity 44''' and a minimum dimension when roller 38''' is in contact with low cam extremity 46'''. However, it should be noted that, due to the rotational movement of the pistons 32–1''' through 32–4''' the radial movement of rollers 38''' is not a constant for a constant unit of rotational movement of the pistons 32–1''' through 32–4''', but rather, radial movement of roller 38''' per unit of rotation of the pistons 32–1''' through 32–4''' decreases with increasing movement of the pistons. For this reason, the forces exerted by rollers 38''' tend to increase as pistons 32–1''' through 32–4''' move downwardly towards their lower extremities. Consequently, as crank arm dimension 170 decreases, the force generated by pistons 32–1''' through 32–4''' increases and a generally constant driving force similar to that developed in conjunction with the involute curve cam surface is generated. Thus these cam portions 52–1''' and 52–2''' may be formed in the shape of any smooth curve. Further, because the rotational moments generated by rollers 38''' are transmitted to rotor 70''' through piston pins 136–1'''through 136–''', it can be seen that as in the other embodiments, the reactive forces generated by the pistons always include a component which acts in a direction perpendicular to crank arm dimensions 36–1''' through 36–4'''.

It will be seen that the piston engine of the invention is more efficient than conventional piston engines since the major portion of the available piston force is exerted throughout the entire piston stroke at a right angle to the effective crank arm, which has the same effective length throughout the power stroke. It will further be seen that the conventional flywheel may be eliminated, cam 26 or rotor member 70 performing the flywheel function.

It will be readily understood that while my invention has been illustrated and described as embodied in an internal combustion piston engine, it is equally applicable to an air engine or compressor.

While there have been described above the principles of this invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of the invention.

What is claimed is:

1. A reciprocating piston machine comprising a rotor member, means for rotatably supporting said rotor member in a casing member for rotation about an axis of rotation, said rotor having a cylinder formed therein in the shape of a sectoral portion of a hollow cylinder having its axis parallel to said first mentioned axis, the curved portion of said hollow cylinder being disposed on said rotor member radially inwardly of the cylinder axis and outwardly of the axis of said rotor member, the radius of said hollow cylinder being shorter than the radius arm between the axes of said rotor member and hollow cylinder, a piston pivotally secured within said cylinder for oscillatory movement therein about said cylinder axis between retracted and extended positions, and generally elliptically shaped cam surface on the interior of said casing member symmetrically disposed with respect to said first mentioned axis and having high and low extremities, said cylinder being on said rotor member, said piston having means engaging said cam surface, said engaging means in said retracted and extended positions of said piston engaging said high and low cam surface extremities, respectively, said cam surface having a curvature such that extensions of said piston causes relative rotation of said rotor member[s] with said engaging means moving over said cam surface from said high to said low extremities thereof.

2. The machine of claim 1 wherein said piston has a cylindrical hub portion disposed coaxially of said axis of said cylinder, an inlet port extending through said hub along a chord thereof and disposed at an angular position wherein said port is opened when said piston is adjacent said extended position and closed when said piston is adjacent said retracted position.

3. The machine of claim 2 wherein said machine is a two-cycle internal combustion engine, there being at least two of said cylinders, each of said cylinders having an exhaust port for exhausting gas therefrom, said extension of said pistons being the power strokes of said engine, said casing member having the opposite end walls thereof respectively carrying means for rotatably mounting said rotor member, said rotor member having an outer cylindrical surface coaxially of said axis and said end walls having wall portions thereof closely adjacent said cylindrical surface whereby said rotor member cylindrical surface and said cam surfaces between said high extremities thereof define two diametrically opposite outer cavities, said inlet ports respectively communicating with said cavities, said rotor member and at least one of said end walls defining another cavity, said exhaust ports communicating with said other cavity, at least one of said end walls having exhaust openings therein communicating with said other cavity, and means for admitting said air-fuel mixture to said outer cavities.

4. The machine of claim 1 wherein said machine is a four-cycle internal combustion engine, said cylinder having an inlet-exhaust port for admitting air-fuel mixture thereto and exhausting spent gas therefrom, said casing member having two opposite end walls respectively carrying means rotatably mounting said rotor member, said two end walls having first and second circumferentially spaced arcuate recesses

therein, respectively, a passage means in one end wall communicating between said first recess and the atmosphere for exhausting spent gases therefrom, a second passage means in the second end wall for admitting said air-fuel mixture to said second recess, said arcuate recesses and said inlet-exhaust ports being equally radially spaced from said rotor axis, said arcuate recesses having end portions in registry with said inlet-exhaust port for one rotational position of said rotor whereby exhaust gases exit said inlet-exhaust port into said first recess concurrently with admission of air-fuel mixture to said second recess, said inlet-exhaust port also sequentially communicating with said first and second recesses during rotation of said rotor member, and means for exploding an air-fuel mixture in said cylinder for a rotational position of said rotor member in which said port is not registered with either of said recesses.

5. The machine of claim **4** wherein said cam surface portion between said high and low extremities being formed as substantially a circle generated about an axis offset from said axis of rotation.

6. The machine of claim **4** in which said exploding means includes a spark plug in one end wall equally radially spaced from said axis at said inlet-exhaust port.

7. The machine of claim **1**, said piston and cylinder having facing surfaces extending generally radially of said rotor member and which define therebetween an explosion chamber, said chamber being disposed radially inward from said cylinder axis, and said piston-engaging means including a roller journalled on said piston for rotation about an axis parallel to said cylinder and rotor member axes, said roller having rolling engagement with said cam surface.

8. The machine of claim **7** in which said piston in its retracted position has its chamber surface closest to the facing cylinder surface of any of its other positions, portions of said piston when in said retracted position lying on opposite sides of an imaginary line drawn between said rotor member axis and said cylinder axis.

9. The machine of claim **8** in which said chamber with said piston retracted has an axis that extends generally radially of said rotor member, an imaginary line through said cylinder axis and the point of contact of said roller on said cam surface defining approximately a right angle or greater with respect to the radial axis of said chamber, the last-mentioned angle increasing with extension movement of said piston.

10. The machine of claim **7** wherein said cylinder includes means for admitting fuel to said explosion chamber and exhausting spent gases therefrom, said casing member including two opposite end members respectively carrying means rotatably mounting said rotor member, means having opposed surfaces that are operatively engageable with said piston and rotor member for defining the opposite sides, respectively, of said explosion chamber.

11. The machine of claim **7** in which said opposed-surface means includes wall members forming opposite sides of said rotor member, said fuel-admitting means including a passage through said piston and said exhaust gas means includes a passage in one of said wall members so positioned to open into said explosion chamber when said piston is extended and to be closed when said piston is retracted.

12. The machine of claim **7** in which said opposed-surface means includes wall members forming opposite sides of said rotor member, a passage in one wall member communicating with said explosion chamber when said piston is retracted and said explosion chamber is smallest, said passage constituting part of said fuel-admitting and exhausting means.

13. The machine of claim **7** in which said opposed-surface means includes wall members forming opposite sides of said rotor member, and including a plurality of said piston and cylinder combinations equally spaced angularly apart on said rotor member, each said piston and cylinder combinations having the aforesaid explosion chamber, sides and means for admitting fuel and exhausting spent gases and the cylinder axes thereof being radially spaced from the axis of said rotor member.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,788,286 Dated January 29, 1974

Inventor(s) John A. Brewer

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

IN THE ABSTRACT

Line 4, change "oscilates" to ---oscillates---.

IN THE SPECIFICATION

Column 1, Line 50, before "two-cycle" insert ---a---;
Column 2, Line 46, change "agaist" to ---against---;
Column 5, Line 57, change "52-2'" first occurrence to ---52-1'---;
Column 5, Line 67, change "spikes" to ---spokes---;
Column 6, Line 11, change "90" to ---98---;
Column 6, Line 46, change "119" to ---118---;
Column 7, Line 42, change "31-1''" to ---32-1'' ---;
Column 8, Line 17, delete "146-" at the end of the line.
Column 8, Line 18, change "145-2" to ---146-2''---;
Column 9, Line 16, change "80" to ---70---;
Column 9, Line 62, change "162" to ---161---;
Column 11, Line 2, change "51-1'''" to ---52-1'''---;
Column 11, Line 48, change "136-''''" to ---136-4'''---;
Column 11, after line 53 and before line 54 insert
---As shown in Figs. 11 and 13, the arcuate portions of the cylinders 24 are situated between the piston pivots and the axis 30 of the rotor member. When the pistons are retracted, as shown more clearly in Fig. 13 with respect to the upper and lower piston assemblies, an explosion chamber of minimum volume is defined between the facing surfaces of each piston and cylinder which extends generally radially of the rotor member. The explosion chamber,

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334.

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,788,286 Dated January 29, 1974

Inventor(s) John A. Brewer

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

therefore, may be considered as having an axis extending generally radially of the rotor member when the piston is closed or fully retracted.

As is more apparent for an examination of Fig. 13, and considering only the lower most piston, portions of the piston lie on opposite sides, respectively, of a radius drawn between the rotor axis 30 and the piston axis 136-2'". Thus, with the piston in its illustrated closed position, portions thereof on opposite sides of this radius counter balance thereby reducing by the extent of this counter balancing the centrifugal force on the piston tending to swing it outwardly around its pivot 136-2'". This counter balancing thereby minimizes the deleterious affects of the centrifugal force tending to throw the piston outwardly during rotation of the rotor member.

Further, with respect to Fig. 13, it will be noted that an imaginary line drawn through the piston or cylinder axis 136-2'" and the point of contact of the roller 38'' on the casing 522'" defines approximately a right angle or greater with respect to the radial axis of the explosion chamber (as above explained) such that as the piston swings outwardly to the position shown of the piston to the right side of Fig. 13, this angle increases.

The internal cam surfaces 52-2', 52-2'' and 52-2'" may be considered as generally elliptical in shape and in certain claims appended hereto are referred to in this manner.---

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—344-334.

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No 3,788,286 Dated January 29, 1974

Inventor(s) John A. Brewer

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

IN THE CLAIMS

Claim 1, Column 12, Line 28, delete "[s]" after ---member---;

Signed and sealed this 10th day of December 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—345-334.