# United States Patent [19]

**Berry**

[11] **3,816,039**

[45] **June 11, 1974**


[54] **ROTARY AIR PUMP WITH ROTATING AND OSCILLATING CENTER PISTON**


[75] Inventor: **Samuel M. Berry,** Dallas, Tex.

[73] Assignee: **Commercial Metals Company,** Dallas, Tex.



[22] Filed: **Dec. 26, 1972**

[21] Appl. No.: **318,107**

**Related U.S. Application Data**

[63] Continuation-in-part of Ser. No. 167,930, Aug. 2, 1971, abandoned.

[52] **U.S. Cl.** ..... **418/68**

[51] **Int. Cl.** ..... **F01c 3/00,** F04c 3/00, F04c 17/00

[58] **Field of Search** ..... 418/68



[56] **References Cited**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 826,985 | 7/1906 | Appel | 418/68 |
| 1,226,864 | 5/1917 | Cyphers et al. | 418/68 |
| 1,678,049 | 7/1928 | Kearney | 418/68 |
| 2,832,198 | 4/1958 | Pichon | 418/68 |

FOREIGN PATENTS OR APPLICATIONS

| | | | |
|---|---|---|---|
| 634,271 | 8/1936 | Germany | 418/68 |
| 755,129 | 4/1955 | Germany | 418/68 |
| 592,586 | 5/1959 | Italy | 418/68 |



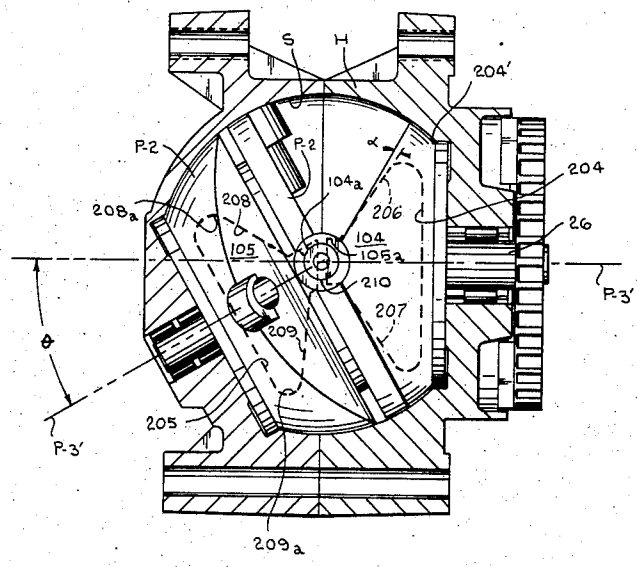
*Primary Examiner*—Carlton R. Croyle
*Assistant Examiner*—John J. Vrablik
*Attorney, Agent, or Firm*—Pravel, Wilson & Matthews



[57] **ABSTRACT**

The present invention pertains to a low pressure rotary spherical air pump for supplying fresh air to an internal combustion exhaust stream to complete combustion of unburned fuel in the exhaust manifold prior to discharge of the exhaust gases in the atmosphere. The spherical air pump comprises front, center and rear pistons rotatably mounted in a spherical chamber with the front and rear pistons pivotally connected to the edges of the center piston by radially extending pins which are mounted in suitable bearing supports on the pistons. The axes of the pins are perpendicular to each other and converge at the center of the sphere and the axes of the forward and rear pistons also converge at the center of the sphere and are disposed at an angle other than 180° with respect to each other so as to cause the center piston to oscillate as it rotates with the front and rear pistons. The spherical housing is provided with improved inlet and discharge ports which enable the spherical air pump to draw in, compress and discharge substantially the total displaceable volume of the pump of each revolution. Also, the front and rear pistons are provided with cylindrical seal areas to seal between such pistons and the surrounding housing.


**9 Claims, 17 Drawing Figures**



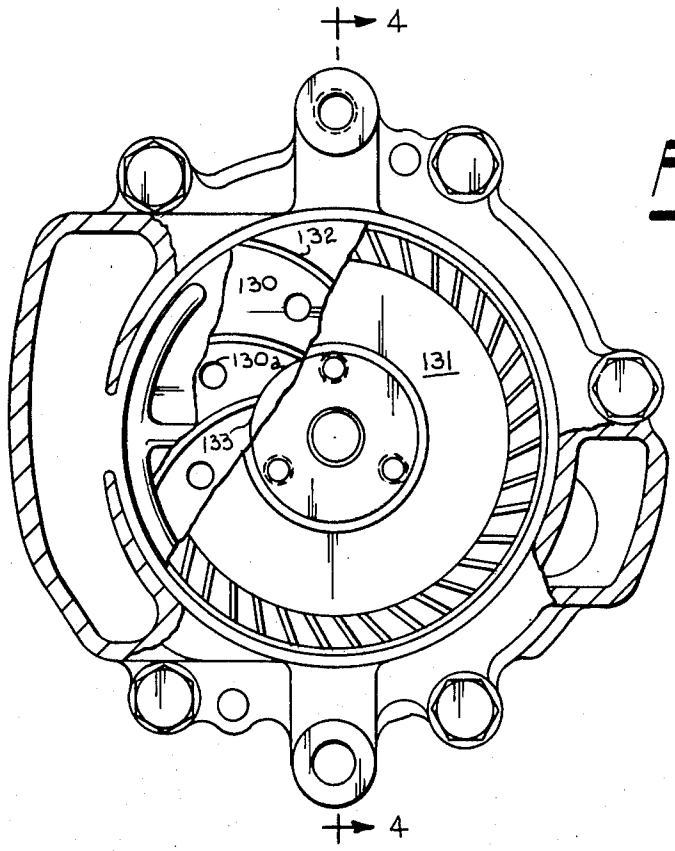



Fig-1

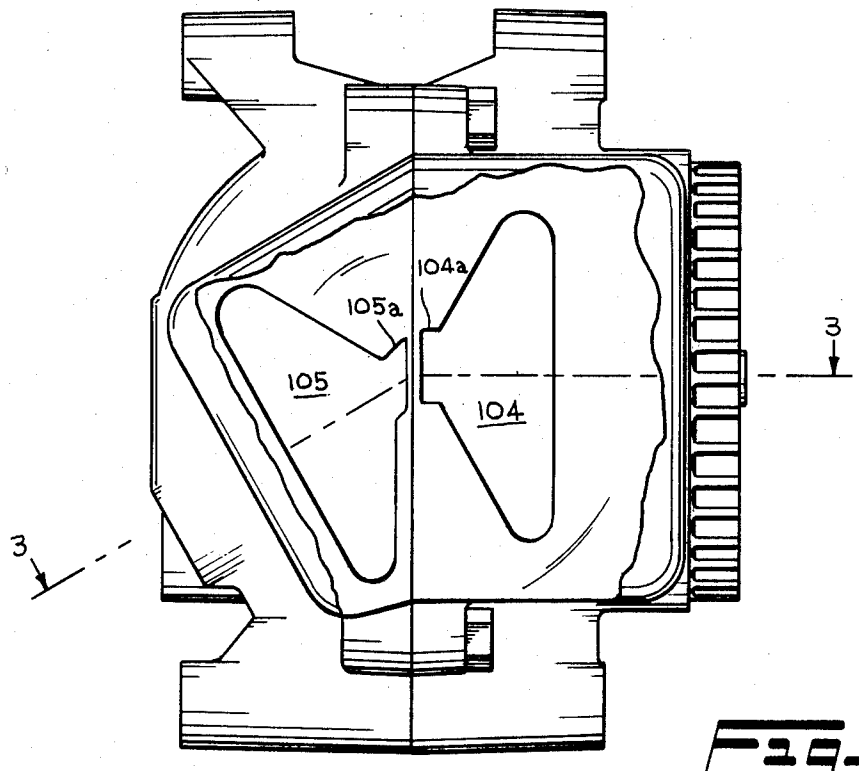



Fig-2

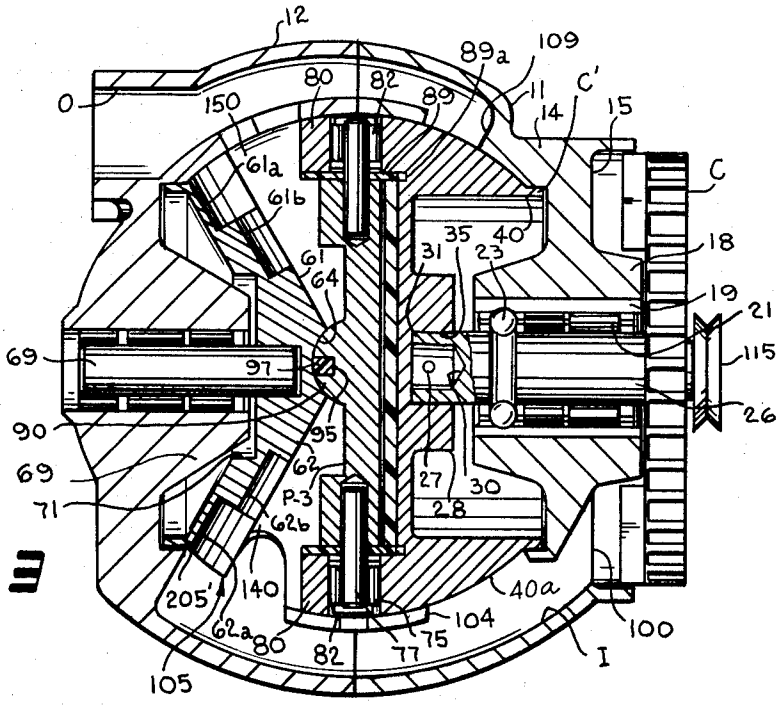

12
89a
109
0
80
82
89
11
C'
14
15
150
61a
61b
C
35
40
31
23
18
61
64
19
21
69
97
115
90
95
26
69
62
27
30
71
P-3
28
62b
205'
140
40a
104
100
62a
80
82
77
75
I
105

Fig-3

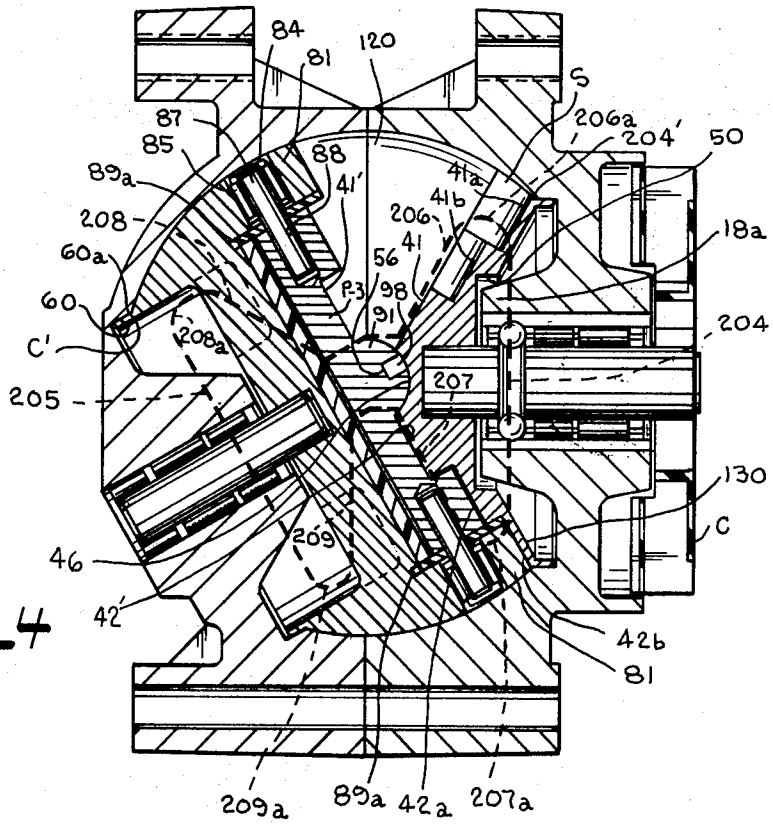
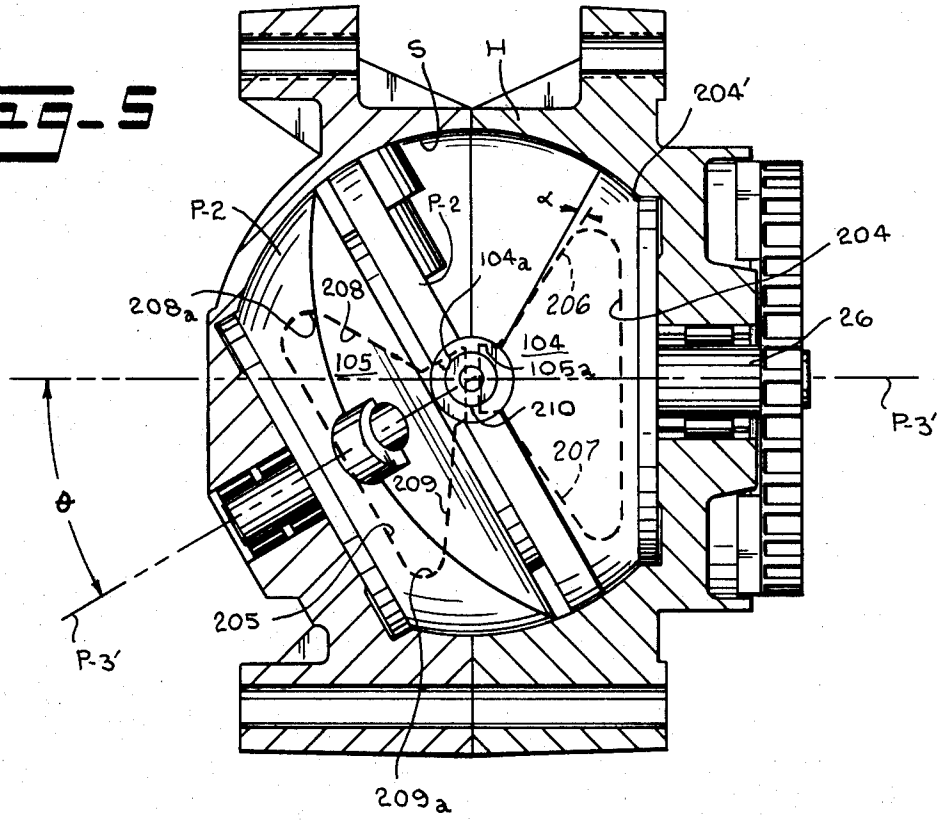

84
81
120
S
87
206a
204'
50
85
88
41'
41a
89a
41b
208
206
18a
60a
41
56
P3
98
60
91
204
C'
208a
207
205
130
209
C
46
42'
42b
81
209a
89a
42a
207a

Fig-4

Fig-5


S
H
204'
P-2
P-2
α
204
104a
208a
208
206
26
104
105
105a
210
P-3'
207
θ
209
205
P-3'
209a

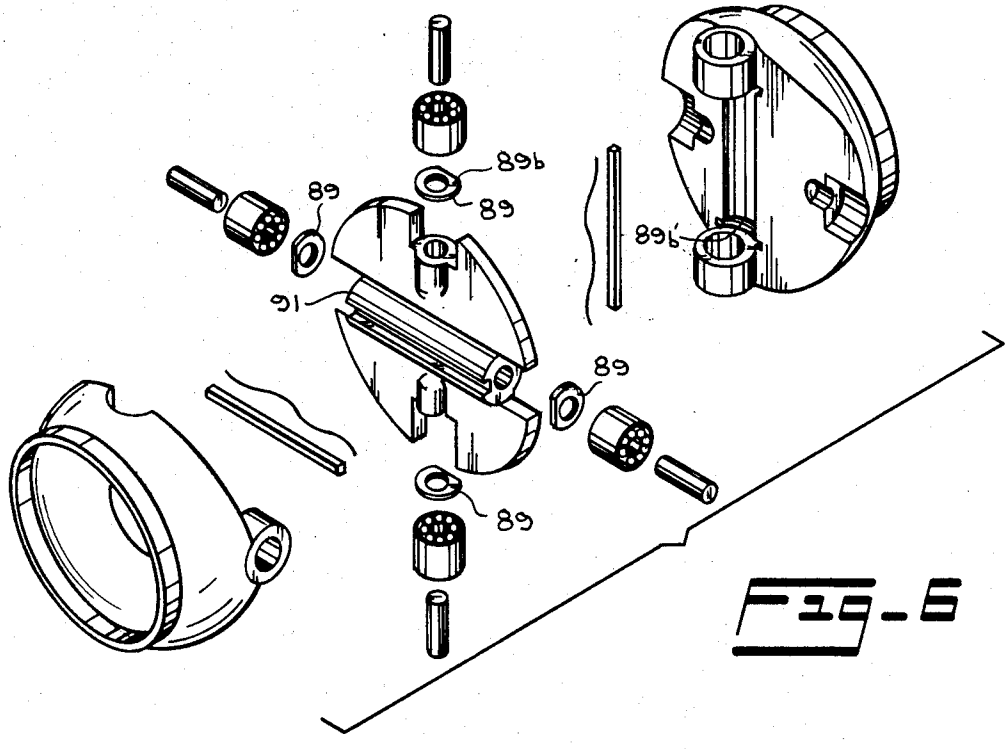

89b
89
89
91
89b'
89
89

Fig-6

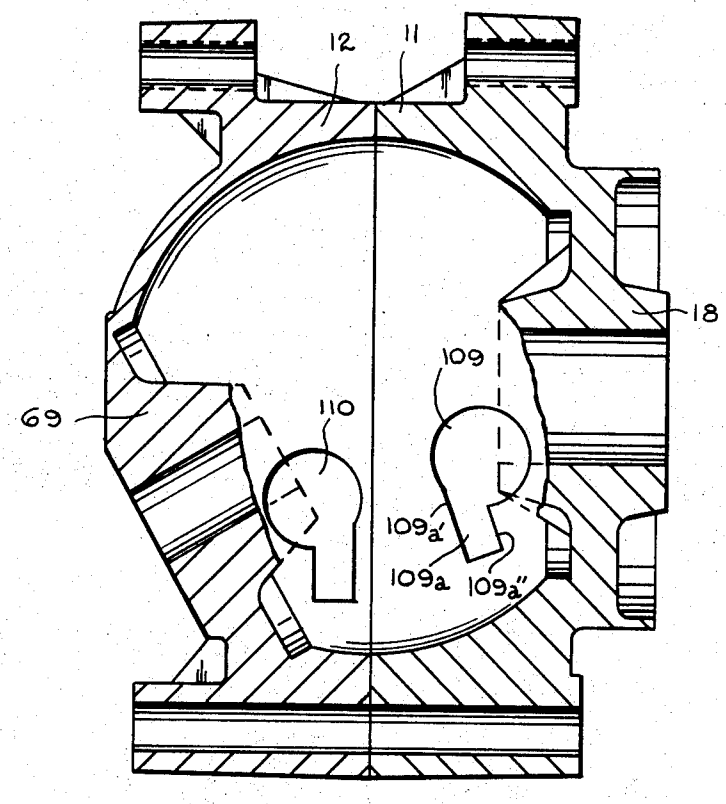



Fig-7

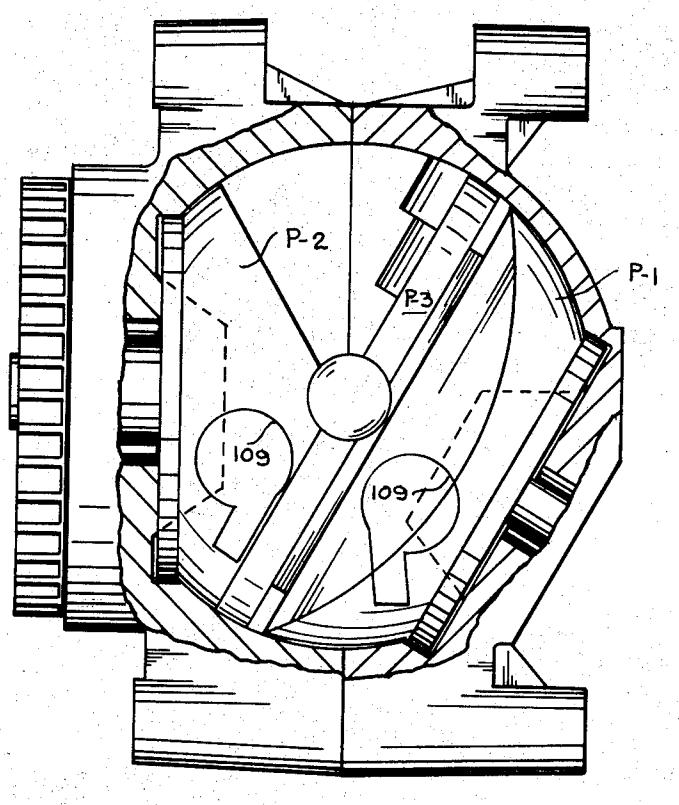



Fig-8

27° ROTATION

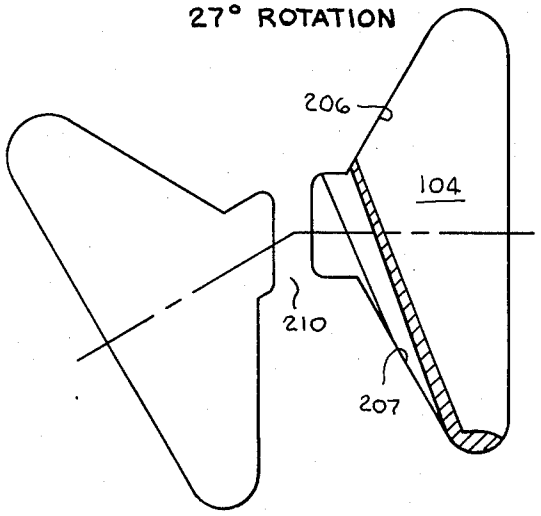



Fig_8A

144° ROTATION

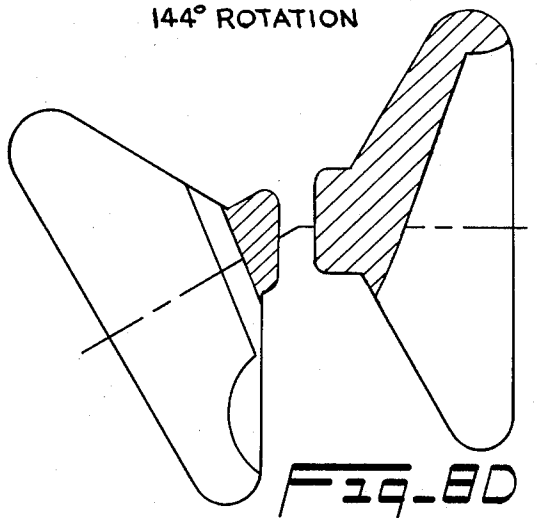


Fig_8D

63° ROTATION

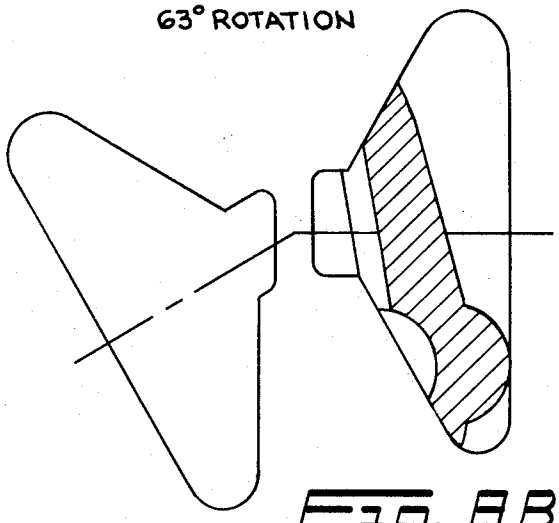


Fig_8B

171° ROTATION

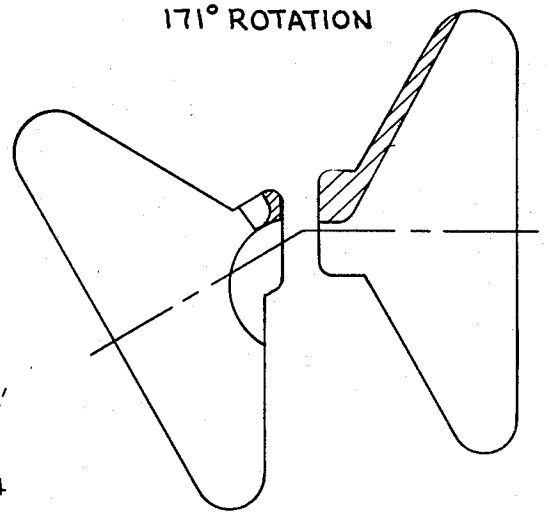


Fig_8E

108° ROTATION

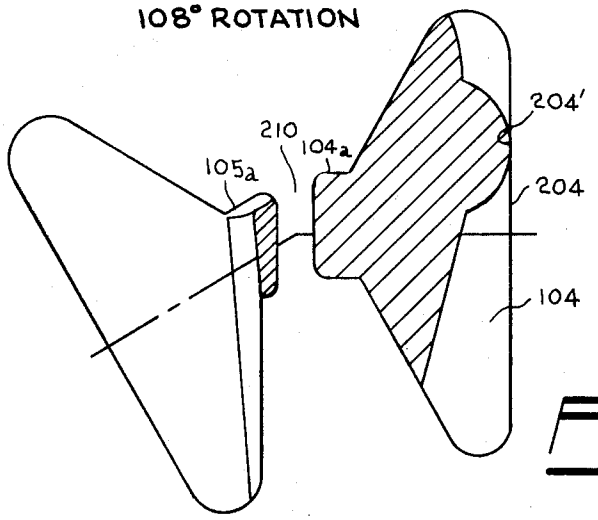



Fig_8C

36° ROTATION

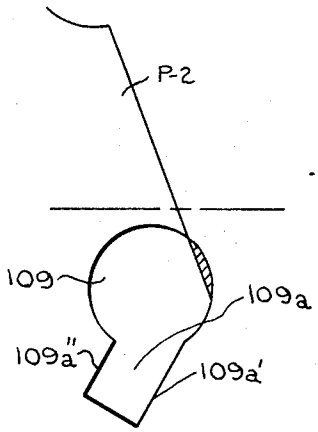



Fig. 9A

135° ROTATION

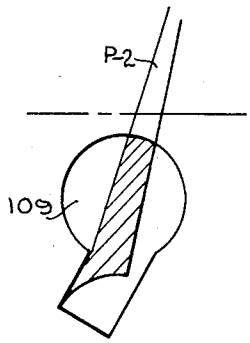



Fig. 9C

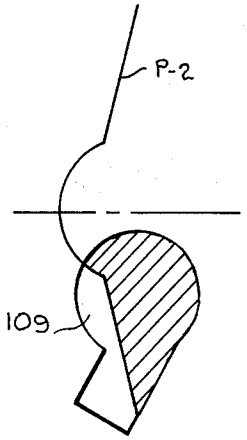



Fig. 9B

90° ROTATION

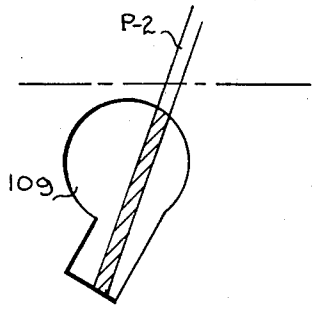



Fig. 9D

153° ROTATION

# ROTARY AIR PUMP WITH ROTATING AND OSCILLATING CENTER PISTON

## RELATED APPLICATIONS

This application is a continuation-in-part of Application Ser. No. 167,930, filed Aug. 2, 1971 and now abandoned.

## BACKGROUND OF THE INVENTION

1. Field of the Invention

The automotive air pump of the present invention pertains to a spherical air pump for providing a continuous flow of low pressure air over a wide range of RPM's and temperatures to supply air to an internal combustion engine exhaust system over the full range of normal operating speeds from idling to maximum RPM's with a minimum of vibration and noise.

2. Description of the Prior Art

Various spherical pump devices have been provided in the prior art which employ wedge-shaped end pistons for rotating and oscillating a center piston. However, such devices do not provide satisfactory inlet and discharge port arrangements for use as an automotive air pump. Further, such prior art devices do not provide seal means for sealing the moving parts so as to enable the pumps to operate at high speed such as several thousand RPM's and at acceptable heat and noise levels.

## SUMMARY OF THE PRESENT INVENTION

The rotary spherical air pump of the present invention comprises a housing having a partially spherical inner configuration with a piston assembly disposed therein. The piston assembly includes forward, center and rear pistons with the forward and rear pistons mounted on opposite sides of the center piston and connected thereto by radially extending pin and bearing assemblies arranged at 90° intervals about the circular central piston. The forward and rear pistons engage the center piston between the bearing assemblies which are disposed adjacent the edges of the central piston. An embodiment also includes a cylindrical skirt seal means for sealing between the forward and rear pistons and the surrounding housing. The apparatus of the present invention also includes a centrifugal separator mounted externally of the spherical housing and operably connected with the forward piston for rotation therewith to separate solid particles from the incoming air stream which flows into the automotive air injection pump of the present invention. Further, the present invention includes a unique porting arrangement for flowing air into and out of the spherical housing so as to maximize efficiency and minimize noise and vibration.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front end view partly in section and partly in elevation showing the air inlet passage and the centrifugal separator;

FIG. 2 is a side elevation view showing additional details of the inlet arrangement and ports of the spherical air pump of the present invention;

FIG. 3 is a sectional view taken on line 3—3 of FIG. 2 showing the piston assembly disposed in the spherical housing;



FIG. 4 is a view taken on line 4—4 of FIG. 1 showing additional details of the piston assembly;

FIG. 5 is a side elevational view showing the piston assembly in elevation with the housing being shown in section;

FIG. 6 is an exploded view of the piston assembly showing the forward, center and rear pistons and the sealing means for sealing between the pistons;

FIG. 7 is a side elevation showing the discharge ports on the spherical housing;

FIG. 8 is a discharge port side view partly in elevation and partly in section;

FIGS. 8A through 8E are a series of schematic views showing the position of the front piston relative to the inlet port at various degrees of rotation from top dead center; and

FIGS. 9A through 9D are a series of schematic views illustrating the relative position of the front piston with respect to the discharge port at various degrees of rotation.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

Briefly, as shown in FIG. 5 of the drawings, the rotary spherical air pump of the present invention comprises a housing H having a concave inner wall forming a partially spherical chamber S therein with forward, center and rear pistons, P-1, P-2 and P-3, respectively, rotatably mounted therein. Such front and rear pistons P-1 and P-3 are pivotally connected to the center piston P-2 by means of radially extending pins and journals, which will be described in detail hereinafter, whereby the center piston P-2 rotates with the front and rear pistons P-1 and P-3, respectively, and simultaneously oscillates therebetween, producing four displacements per revolution. The pistons P-1 and P-3 have their respective axes P-1′ and P-3′, respectively, inclined at an angle $\theta$ with respect to each other which produces a center piston stroke of $2\theta$ per revolution.

As shown in FIG. 3 of the drawings, a centrifugal separator C is mounted at one end of the spherical housing H adjacent the inlet passage I for removing solid particles from the incoming air stream which is drawn into the spherical chamber for compression and subsequent exhaust or discharge through the outlet conduit O.

With the apparatus of this invention operably connected to an automobile internal combustion engine, the air pump furnishes a continuous stream of fresh air for supplying fresh air to the automobile exhaust manifold for mixing with unburned fuel in the exhaust gas stream to thereby complete the ignition of fuel prior to discharge from the exhaust system into the atmosphere.

Considering now the apparatus of the present invention in more detail as shown in FIGS. 3 and 4 of the drawings, the housing H is preferably formed of a pair of mating half sections 11 and 12 which are made of die cast aluminum or other suitable material and which are doweled and bolted together by suitable dowels and connecting bolts (not shown) to form a unitary housing H in which the pistons P-1, P-2 and P-3 are received.

The forward end section 11 includes a cylindrical neck portion 14 surrounding a web 15 that carries a bearing support 18 which has a bore 19 therein into which are pressed roller bearings 21 as well as a ball bearing assembly 23. The dual bearing arrangement is

provided in the preferred form of this invention to support the piston shaft 26 which is secured at one end to the piston P-1 and at the opposite end to the drive pulley 115. In the preferred form of this invention, the piston shaft 26 is formed of hardened steel and connected to the piston P-1 by a press fit and also by means of a lock pin or retainer 27 which extends through a suitable opening in the piston neck 28 and the shaft 26. However, the piston shaft may be formed integrally with the piston body, if desired.

As shown in FIG. 3 of the drawings, the steel drive shaft 26 has a counter bore 30 adjacent its inner end to provide a relatively thin circumferentially extending wall 31 or tube section at its inner end which is inserted into the bore 35 in the aluminum neck piston 28. Inasmuch as the automotive air injection pump of the present invention may be subjected to a range of temperatures from −40° F. to 250° or 300° F., the hollow tip arrangement on the steel shaft enables the steel shaft to deform so as not to crack the cast aluminum piston as a result of differences in thermal expansion of the two metals. Since the coefficient of thermal expansion of aluminum is approximately twice that of steel, a very tight press fit at ambient temperature of approximately 70° F. is necessary to obtain a moderate press fit at elevated temperatures of say 250° F. For this case and a solid steel shaft, when the temperature is lowered to subzero, the press fit would become so great as to overstress the aluminum and cause it to yield, whereas, a tubular shaft such as is shown would deflect with less load which would impose less stress on the aluminum piston. The higher yield strength of the steel allows it to deflect more than the aluminum without yielding and thus when temperature is again elevated, the tube would return to its former moderate or highly stressed condition.

As shown in FIGS. 3 and 4, the body of the piston P-1 comprises a wedge-shaped spherical section having a cylindrical skirt 40 extending circumferentially thereof which is of substantially the same radius as the cylindrical bore C′ in the housing H and a spherical back portion 40*a*.

The cylindrical skirt provides a longer sealing length at the rear of the spherical piston without increasing the weight of the piston and the cylindrical part of the piston can easily be machined to closer tolerance with the surrounding cylindrical bore in the housing H to provide an improved seal between the end piston and the surrounding housing. Such piston body has a pair of converging plane surfaces 41 and 42 which are provided with recesses or relieved areas 41*a* and 41*b* and 42*a* and 42*b*, respectively, for receiving the connecting journal means for connecting the front piston P-1 to the center piston P-2 as will be described hereinafter. Further, the piston P-1 is provided with a diametrically extending groove 46 which extends between the converging edges of the plane surfaces 41 and 42 for receiving the curved journal portion of the center piston P-2 as will be described in detail hereinafter.

Also, the rear side of the piston is provided with a recess 50 to provide clearance for the rear end 18*a* of the shaft support 18.

The piston P-3 is substantially identical to the die cast aluminum piston P-1 in that it has a cylindrical skirt 60 which is received in the cylindrical opening C′ in the housing H. The piston P-3 is rotatably mounted on a pin or shaft 65 which is carried on bearings 66 and 67 in bore 68 of the shaft support neck or sleeve 69 in the rear housing section 12. The piston P-3 has a pair of inclined or converging plane surfaces 61 and 62 with a longitudinally extending groove 64 between adjacent edges of such faces 61 and 62. The faces 61 and 62 are each provided with recesses 61*a* and 61*b* as well as 62*a* and 62*b*, respectively, for receiving the connecting journal portion of the central piston P-2 as will be described in detail hereinafter. Further, the rear side of the piston P-3 is provided with relieved areas 71 for clearance with respect to the shaft support sleeve 69 which carries the shaft 65 for rotatably mounting the piston P-2 in the rear housing 12.

In the preferred form of this invention, each of the pistons P-1 and P-3, respectively, are provided with a pair of bearing supports 80 and 81, respectively, which are either formed integrally with the pistons P-1 and P-3 or are secured to the respective pistons by resistance welding or other suitable securing means. As shown in the drawings, such bearing support members 80 are provided with bores 82 which are aligned on a common diametrically extending axis, and similarly, bearing support members 81 which are secured to the rear piston P-2, are also provided with bores 84 that are aligned on a common diametrically extending axis. Needle roller bearings 75 and 85 are pressed into the bores 82 and 84, respectively, and over steel pins 77 and 87, respectively, for securing the pistons P-1 and P-2, respectively, to the center piston P-3. The steel connecting pins 77 and 87 are pressed into suitable bores 78 and 88 in the center piston P-3. Also, in the preferred form of this invention, thrust washers 89 are positioned between the bearing supports 80 and 81 and the adjacent ends of the semi-cylindrical journals 90 and 91 on the center piston P-3. The outer pistons P-1 and P-2 are slot milled at 89*a* to provide a means for securing the washers in the pistons. Also, each washer is provided with a flat side 89*b* which engages a flat surface 89*b*′ in the slot 89 to hold the washer against rotation relative to the end pistons. Also, it will be appreciated that the drawn cup needle roller bearings 75 and 85, respectively, are provided with a permanent seal for maintaining lubricants therein and similarly, the roller bearing and ball bearings around the shafts P-1 and P-3, respectively, are also provided with suitable seals to retain the permanent lubricant in such bearings.

Semi-cylindrical journals 90 and 91 are provided on opposite sides of the central piston P-2 and such semi-cylindrical journal members extend diametrically of the center piston and between the opposite journal members 80 and 81, respectively. Such journal members 90 and 91 are received in the grooves 46 and 64 of the front and rear pistons, respectively. As shown in the drawings, longitudinally extending notches or recesses 95 and 96 are provided in the semi-cylindrical journals 90 and 91 for receiving suitable spring loaded strip seals 97 and 98 which seal between the semi-cylindrical journals in the respective adjacent grooves 46 and 64. Such strip seals are preferably made of "Sparmon 517" which is a product of Sparta Mfg. Co., Dover, Ohio. However, the seals 97 and 98 and slots 95 and 96 can be omitted when a clearance fit is provided between the journals 90 and 91 and the grooves 46 and 64.

Also, in the preferred form of this invention the outside diameters of the three rotating parts are coated with an abraidable coating of dry film lubricants which is crushed during assembly to provide a close fit be-

tween the rotating parts and the surrounding outer housing and to prevent metal-to-metal contact between such rotating pistons P-1, P-2 and P-3 and the spherical surface in the housing H.

Further, as shown in FIG. 4 of the drawings, a sharp edge 60*a* is provided where the cylindrical bore C' meets the spherical chamber C so that the sharp edge will wear a clearance fit in the dry film lubricant to provide an excellent seal between the rear piston and the surrounding housing.

As shown in FIG. 3 of the drawings, the inlet passage I has an opening 100 adjacent the centrifugal separator C at the front of the housing H for bringing air into such passage I. The passage I extends rearwardly along the side of the housing H through the forward housing portion 11 and terminates at the side of the rear housing portion 12. Such inlet passage I is provided with ports 104 and 105 for conducting air into the chambers formed on opposite sides of the central piston P-2. As shown in FIG. 4, forward chambers 120 and 130 are provided between the piston P-1 and the piston P-2. The forward chamber 120 is bounded by the surfaces 41 on the piston P-1 and by the corresponding surfaces 41' on the center piston P-2 as well as the inner surface of the surrounding spherical housing. Similarly, the chamber 130 is bounded by the surface 42 on the piston P-1 and the facing adjacent surface 42' on the piston P-2 as well as the surrounding housing H. Air flowing into the inlet passage I passes into the forward chambers 120 and 130 through the inlet port 104 and after being compressed in such chambers is discharged through the outlet port 109 and then through the outlet passage O, as will be described in more detail hereinafter.

Similarly, as shown in FIG. 3 of the drawings, the rear piston and the center piston P-2 define chambers 140 and 150, respectively. The chamber 140 is bounded on opposite sides by surfaces 62 and 64' on the pistons P-3 and P-2, respectively, by the inner surface of the spherical chamber in the housing H. Further, the chamber 150 is defined by the facing surfaces 61 and 61' on the pistons P-3 and P-2, respectively. As shown in the drawings, each of the faces on the end pistons includes indentations or relieved areas such as 61*a* and 61*b* which receive the bearing support portion 80 of the center piston P-2. Air passing through the inlet passage I enters the rear chambers 140 and 150 through the inlet port 105 and passes through such chambers and is discharged via the discharge port 110 and the discharge passage O.

Considering the inlet ports in more detail as shown in FIGS. 5 and 8A-E, respectively, the inlet port 104 has a forward edge 204 which is substantially perpendicular to the axis of rotation P-1' of the forward piston P-1. The edge 204 is positioned so as to cover the arc described by the points 204' which are the points on the piston P-1 which are adjacent the radius of the inner spherical surface S and which are nearest to the axis P-1 of the piston P-1. Thus, it will be appreciated that the position of the edge 204 provides a seal with respect to the chambers 120 and 130 and yet provides for the largest practical opening for the port 104 which may be successfully valved by the rotation of such piston P-1. The forward inlet port 104 is provided with upper and lower angular edges 206 and 207, respectively, each of which is disposed at an angle with respect to the inclined faces 41 and 42 of the forward piston P-1 when such piston P-1 is at the top dead center position as shown in FIG. 4 of the drawings. However, in some embodiments, the edges 206 and 207 may be disposed substantially parallel to the inclined piston faces 41 and 42 at TDC. As will be noted, the upper edge 206 is positioned coincident to or slightly overlapping the edge of the piston face 41 at TDC while the edge 207 is positioned to completely overlap the inclined face 42 so as to provide a seal at the edge of the piston face to prevent high pressure fluid from leaking back from the other chamber formed between the end piston P-1 and the center piston P-2. The inclined edges 206 and 207 are connected to the edge 204 by curved edge portions 206*a* and 207*a*, respectively, and, in the preferred embodiment of the present invention, the radius of the upper curve 206*a* is slightly larger than the radius of the lower curve 207*a* due to the overlap of such edge 207.

Similarly, the inlet port 105 is defined in part by its rear most edge 205 which is disposed substantially perpendicular to the axis P-3' of the rear piston P-3 and which is positioned so as to seal the arc or circle described by the points 205' on the piston P-3 which are those points which are adjacent the radius of the inner spherical surface S and which are also nearest the axis P-3' of such piston P-3.

Similarly, the rear inlet port 105 is provided with inclined edges 208 and 209, respectively, which are in planes that are inclined slightly relative to the inclined faces 61 and 62 of the rear piston P-3 when such rear piston is in the top dead center position in the housing H. Further, the inclined edge 208 is connected to the edge 205 by curved edge portion 208*a* and the inclined surface 209 is connected to the edge 205 by curved edge 209*a*.

Also as shown in FIG. 2 of the drawings, the ports 104 and 105 are connected together by means of neck portions 104*a* and 105*a*, respectively, and, as shown in the drawings, the width of such connecting neck portions 104*a* and 105*a* is slightly narrower than the diameter of the journal support members 80 and 81, respectively. As shown in FIG. 4 the length of the inlet port 104 is determined by the point 204' at the juncture of the relieved area 61*a* and the cylindrical skirt 30. Also, as will be seen in FIG. 8C of the drawings, the center piston P-2 sweeps across the neck area 104*a* and 105*a* upon each revolution. The neck portion 105*a* forms a part of the inlet 104 for purposes of drawing air into the forward chambers 120 and 130, respectively. Similarly, the neck portion 104*a* forms a part of the inlet portion 105 for drawing air or fluid into the rear chambers 140 and 150. Thus, as the center piston sweeps back and forth across the neck areas 105*a* and 104*a*, the neck portions serve as part of the inlet or alternately the front and rear chambers. Further, attention is directed to the bridge member 210 which is formed at the abutting edges of the front housing 11 and the rear housing 12 and is provided to hold the circular or spherical configuration of such housing so as to prevent distortion of the spherical surface of the inner housing during machining or during use.

Referring now to FIGS. 8A through 8F, respectively, there is shown the relative positions of the piston P-1 with respect to the inlet ports 104 and 105 which illustrates graphically the opening and closing of such ports upon rotation of the piston P-1.

As seen in FIG. 8A, the edge 207 of the inlet port 104 is the first edge valved open when the piston P-1 is rotated clockwise as viewed from the front or pulley end. The edge of the port first valved open by the piston is disposed approximately 1/8 inch past the top dead center so as to provide a seal during the entire discharge stroke. Similarly, the edge 206 which is the last edge valved closed, coincides with the edge of the piston face 41 or 42 as the case may be, when the piston P-1 is at bottom dead center so as to allow the maximum amount of air to be taken into the pump without reducing its net effective displacement (FIG. 8F).

A series of drawings 9A through 9E illustrates the relative positions of the piston P-1 with respect to the discharge port 109.

As shown in FIGS. 9A through 9E of the drawings, the discharge port 109 comprises a circle having a rectangular extension 109*a* with parallel sides 109*a'* and 109*a''* and, as shown in the drawings, the circular opening 109 is positioned tangentially with respect to the piston face at top dead center and the side 109*a* is parallel to the edge of the piston face but is set back some small distance such as 0.04 inch from the piston face at top dead center. The addition of the rectangular area to the port greatly increases the critical area for discharging fluid from the chambers and thus enables the pistons to displace substantially all of the air from such chambers on each revolution. Also, the discharge ports are positioned so as to be opened by the pistons after the suction or inlet passage has been closed. In the preferred form, the piston P-1 is rotated approximately 30° past TDC (FIGS. 9A and 9B) after the inlet port is closed and before the discharge port 109 is opened. Thus, the fluid in the chamber 120 or 130, as the case may be, is compressed through such 30° rotation prior to discharge. The advantage of this porting arrangement is to minimize the time the pumping chamber is exposed or in communication with the high pressure line which reduces work and also leakage. Further, this arrangement provides maximum seal length on the outer piston without increasing the size of the pump.

It will be appreciated that the pulley 115 which is shown connected to the forward end of the shaft 26 is connected to a suitable V-belt drive for connection to an internal combustion automobile engine (not shown) or other suitable drive apparatus for rotation the pistons P-1, P-2 and P-3 as well as the centrifugal separator C.

As shown in FIGS. 1 and 2 of the drawings, the centrifugal separator C comprises a pair of longitudinally spaced discs or plates 130' and 131 having a plurality of vanes 132 disposed therebetween which extend radially outwardly from a central hub 133 mounted on the forward shaft 26. Rotation of the piston assembly in the spherical housing creates a negative pressure at the inlet port 100 thus drawing air between the vanes 132 and through the openings 130*a* into the inlet conduit I. Rotation of the vanes 132 moves solid particles in the air stream outwardly away from the inlet port 100 to provide a substantially solid particle-free stream of incoming air which is then compressed in the air pump of the present invention.

It will be appreciated that rotation of the pulley 115 causes the centrifugal separator C as well as the pistons P-1, P-2 and P-3 to rotate simultaneously and, that the center piston P-2 is caused to oscillate through an angle of 2$\theta$ upon each revolution of the piston assembly. Such oscillation alternately opens and closes the four chambers in the spherical housing which are formed between the inclined faces or surfaces 41, 42, 61 and 62 on the pistons P-1 and P-3 and their adjacent surfaces on the center piston P-2. In the embodiment shown in the drawings, the center piston passes through four complete displacements or exhaust cycles per revolution. By way of example, upon each revolution of the piston assembly, the center piston P-2 moves toward and away from each of the inclined surfaces or piston faces 41, 42, 61 and 62, respectively. It will be appreciated that as the pistons P-1 and P-3 pass the inlet openings 104 and 105, respectively, the pistons act as valves to open communication through the inlet ports and thereby allow air to be drawn into the various chambers as the center piston P-2 oscillates away from the adjacent inclined faces 41, 42, 61 or 62, as the case may be. Similarly, air is compressed as the center piston moves toward each of its adjacent inclined surfaces 41, 42, 61 and 62, and such compressed air is discharged through the outlet ports or passages 109 and 110 so as to cause compressed air to pass outwardly from the spherical air pump through the discharge conduit O.

The inlet ports 104 and 105 and the discharge ports 109 and 110 are valved by the rotating pistons P-1, P-2 and P-3 to control the flow of low pressure incoming and high pressure discharge air therethrough and to prevent leakage from the high pressure to the low pressure chambers. With the piston P-1 at the top dead center position shown in FIGS. 3 and 4 of the drawings, the chamber 120 is fully open and the chamber 130 is fully closed; each of the chambers 140 and 150 are positioned midway between full open and full closed. As the pistons rotate in a clockwise direction from the top dead center position, the chamber 130 begins to open as it passes the inlet port 104 thus creating a negative pressure and drawing fresh air into the chamber 130 through the inlet conduit I. Rotation clockwise through a 180° intake strike moves the chamber 130 to the full open position, which is a position in which chamber 120 is shown in FIG. 4. In this position the end of the bearing support 80 and the spherical back 40*a* close the inlet port 140 so that the increased pressure which results in the chamber 130 during the following 180° of rotation (exhaust stroke) will not leak back into he inlet passage I. Further, the skirt 40 also provides a seal between the piston and the housing. When the chamber 130 is in the full closed position, chamber 120 is in the full open position. Rotation clockwise 180° provides an exhaust stroke to discharge air from the chamber 120 and an inlet stroke to draw air into the chamber 130. When the piston P-1 reaches the FIG. 4 position, the spherical back position 40*a* of the pistons P-1 and P-2 close the discharge port 109. Thus, the pistons valve the inlet and discharge ports as well as compress the air as it is moved through the pump of the present invention. It will be appreciated that the bearing support members 80 and the spherical side of the pistons P-1 and P-2 valve the inlet and discharge ports for the rear chambers 140 and 150 in the same manner that the pistons valve the chambers 120 and 130 as described hereinabove.

As shown in the drawings, the inlet and discharge ports are on opposite sides of the spherical housing H and in a position so as to be fully closed in the chambers 120 and 130 when one of such chambers is fully

opened and the other is fully closed. However, it will be appreciated, that the inlet and discharge ports could be angularly spaced clockwise or counterclockwise from the position shown in the drawings approximately some small amount without a serious loss in the volumetric efficiency of the air pump of the present invention.

The foregoing disclosure and description of the invention are illustrative and explanatory thereof, and various changes in the size, shape and materials as well as in the details of the illustrated construction may be made without departing from the spirit of the invention.

I claim:

**1.** In a rotary spherical air pump comprising:

a. a housing having a concave inner wall forming a partially spherical chamber in said housing;

b. inlet and discharge ports in said housing for communicating air to and from said partially spherical chamber;

c. front and rear wedge-shaped end pistons disposed in said partially spherical chamber;

d. each of said wedge-shaped end pistons having a pair of inclined faces in a partially spherical back of substantially the same radius as the radius of said partially spherical chamber and rotatable therein with a recess formed adjacent the intersection of said inclined face and said spherical back to provide a passage for communicating air into and out of said partially spherical chamber;

e. shaft means for rotatably mounting said end pistons in said chamber with the longitudinal axis of each of said shafts being disposed in angular relationship to the other and intersecting at the center of said partially spherical chamber;

f. a center piston disposed in said partially spherical chamber between said end pistons; and

g. substantially triangular inlet ports in said housing communicating said partially spherical chamber with the base of said triangular inlet port substantially perpendicular to the axis of rotation of said end piston and parallel to and disposed adjacent the arc described by the rotation of the point on the intersection of said recess and said partially spherical back nearest the axis of rotation of said end piston.

**2.** The invention of claim **1** wherein said substantially triangular inlet ports include first and second sides, and wherein said first side is first valved open by rotation of said end piston and wherein said first side is disposed in non-parallel relationship to the adjacent edge of the inclined face of said end piston when said end piston is rotated away from Top Dead Center position, and wherein said second side is valved closed by rotation of said end piston and wherein said second side is disposed in non-parallel relationship to the adjacent edge of the inclined face of said end piston when said end piston is rotated to Bottom Dead Center.

**3.** The invention of claim **1** wherein said inlet ports for said front and rear end pistons are interconnected so as to communicate incoming fluid into the chamber adjacent each of said end pistons from the inlet port adjacent the other of said end pistons.

**4.** The invention of claim **1** wherein said inlet ports are valved open and closed by said end pistons and said center piston and said inlet port begins opening between 0° and 10° of rotation of said end piston past top dead center and remains open to substantially 180° past top dead center.

**5.** The invention of claim **1** wherein said shaft means for mounting said end pistons are steel and include a hollow tubular end portion press fit into a bore in said end piston and wherein each of said end pistons is aluminum.

**6.** The invention of claim **1** including a seal means comprising a cylindrical skirt extending circumferentially of such end pistons and said cylindrical skirt being coaxial with the axis of rotation of said pistons and wherein said housing has a cylindrical bore which is coaxial of said axis of rotation of each of said end pistons for receiving said cylindrical skirt portion to form a seal therebetween.

**7.** The invention of claim **1,** including:

discharge ports in said partially spherical housing and having a generally circular configuration with a rectangular extension therewith, the longer side of such rectangle being substantially tangential to the circular opening and substantially parallel to the plane of the inclined face of the adjacent end piston when such piston is at top dead center.

**8.** The invention of claim **7** wherein said discharge port is positioned so as to be opened by rotation of the adjacent piston after it has rotated at least 30° through the discharge stroke.

**9.** The invention of claim **7** wherein said discharge ports are angularly spaced so as not to begin opening at intervals of 90° of rotation of said center piston.

* * * * *