LOW PRESSURE ROTARY VALVE DIAPHRAGM AIR PUMP

United States Patent Office

3,149,777

United States Patent Office 3,149,777

Patented Sept. 22, 1864

Thompson-Woolridge, Inc.

Cleveland, Ohio

Assignor to Thompson-Woolridge, Inc.

Filed Apr. 3, 1961, Ser. No. 100,178

This invention relates generally to pumps and more particularly relates to a combined double acting pump and valve mechanism for delivering large quantities of air at low pressure. Although the pump of the present invention is of general applicability, a particularly useful embodiment is shown when incorporated in a device for smog control known as an afterburner, as used on automobiles and other types of gasoline engines.

In this connection, it has been established that exhaust gases left after automobile engine combustion tend to cause smog in congested urban areas. In order to eliminate such menace, it is contemplated by the present invention that such residual exhaust gases will be heated to a temperature capable of supporting combustion while providing air in proper volume to maintain combustion until the harmful gases are destroyed. The pump provided to accomplish that end is used as a means of supplying the required amount of air for combustion purposes, although the pump could have other uses independent of such an organization since the pump would be useful in any organization wherein low pressure and high volume is needed, as, for example, in spray painting machines and in certain types of gas pumps.

It is an object of the present invention to provide an air pump that will deliver a large volume of air at low speed.

Another object of the present invention is to provide a pump with quiet valves without the clutter of poppet and flapper type valves.

A still further object of the invention is to provide a pump which is economical to produce and which can be constructed of smaller components relative to the air moving capacity and which is made of a reduced number of parts affording long life with minimum maintenance.

Yet another object of the present invention is to provide a pump that will pump air contaminated with foreign particles without injuring the pumping mechanism.

A still further object of the invention is to provide a pump which will not require oil in the pumping chamber to lubricate the pumping means as is required in a piston or other type pump, thereby to keep oil out of the air which is to be used to promote combustion of the exhaust gases already heavy with unburned hydrocarbons.

A further object of the invention is to provide a pump which can be readily and conveniently installed on an automobile engine in connection with a so-called automatic afterburner.

Yet another object of the invention is to provide a pump mechanism that is well balanced and free from excessive vibration.

Many other features, advantages and additional objects of the present invention will become manifest to those versed in the art upon making reference to the detailed description which follows and the accompanying sheets of drawings in which a preferred structural embodiment of the invention is shown by way of illustrative example.

On the drawings:

FIGURE 1 is a cross-sectional view taken on line I—I of FIGURE 3;

FIGURE 2 is a cross-sectional view taken on line II—II of FIGURE 3;

FIGURE 3 is a cross-sectional view taken on line III—III of FIGURE 1;

FIGURE 4 is a bottom plan view of the pump of FIGURES 1–3; and

FIGURE 5 is a view generally similar to FIGURE 1 but showing an alternative embodiment of the present invention with the top diaphragm bearing removed and a longer lower bearing substituted.

As shown on the drawings:

The fluid displacement means of this pump is primarily a diaphragm 1 which is clamped at its outer extremity between an upper housing 2 and a lower housing 3. Its inner edges are clamped between an upper driving plate 4 and a lower plate shown at 5.

The upper and lower housings 2 and 3 are clamped together by suitable fasteners such as screws 6, while the inner parts including the upper driving plate 4 and the lever plate 5 are clamped together by suitable fastening means such as the screw 7, thereby holding the diaphragm.

Since the diaphragm extends across the hollow interior of the casing formed by the upper and lower housing parts, the pumping cavity prescribed by the casing is partitioned into an upper pumping chamber 12 and a lower pumping chamber 13. Thus, upon reciprocation of the diaphragm 1, portions of the diaphragm, as indicated at 8, will flex as the diaphragm is moved up and down and displaces air first in the upper pumping chamber 12 and then in the lower pumping chamber 13. Accordingly, the pump develops a double pumping action.

In order to impart the necessary reciprocation to the diaphragm 1, suitable actuating means are provided including a slide yoke 9 supported in a bearing 10 in the upper housing 2 and by a bearing 11 in the lower housing 3. The diaphragm plates 4 and 5 are clamped to the slide yoke 9 by a nut 14.

The actuating means further comprise a crank 15 carried on a valve shaft 16. The crank 15 is connected to the slide yoke 9 by a connecting rod shown at 17 and a wrist pin 18. The connecting rod 17 has a cap 19 to facilitate its assembly.

In order to afford splash lubrication of moving parts, a crank case chamber 20 is formed within the casing and carries oil, as shown at 21, filled to a level determined by an oil level plug 24 located in one wall of the chamber 20.

A bellows 22 is clamped between the plate 4 and the slide yoke 9 at its upper end and is anchored in the lower housing 3 by a snap ring 23. Thus, oil is sealed out from the pumping chamber 13. The crank case chamber 20 is vented through a vent pipe 25 located in an upper side wall of the oil chamber. A cap 26 covers the open side of the casing extending into the crank case.

In order to center and anchor the diaphragm 1, a bead 27 is molded onto the outer periphery of the diaphragm 1 and a bead 28 is provided on its inner periphery. Corresponding recesses are formed in the casing and the lever plate 5.

The crank and valve shaft 16 is supported on each end by a ball or roller bearing 29 at one end and 30 on the opposite end. The shaft 16 is also provided with a snug running fit in the lower housing 3 on each side of the crank case chamber 20.

In accordance with the principles of the present invention, the valve shaft 16 is formed with four semicircular or segmental peripheral grooves, two on each side of the crank cavity, or crank case chamber 20. The four grooves are identified at 31, 32, 33 and 34.

Between the two grooves 31 and 32 on the one side of the pump, there is provided a complete or peripherally continuous annular groove 35. A similar peripherally continuous groove 36 is formed on the opposite side of the pump between the two grooves 33 and 34.
3,149,777 A tapped inlet port 39 is formed in the casing in communicating register with the peripherally continuous groove 35, while a tapped outlet port 49 is formed in the casing in communicative register with the peripherally continuous groove 36.

The lower pumping chamber 13 has two openings, 43 on the left and 41 on the right, using the orientation of the drawings presented herewith. Such openings or holes register with the segmental groove 32 on the left and with the segmental groove 33 on the right approximately each one-half revolution of the crank and valve shaft of the lower pumping chamber 13.

In like manner, the upper pumping chamber 12 has an opening 44 on the left and an opening 43 on the right. By means of a hole 45, as shown in FIGURE 2 and FIGURE 4, the opening 43 in the upper housing 2 is carried down at an angle to register with the segmental groove 34. Also, the other opening 44 in the upper housing 3 is led down to register with the segmental groove 31 during a half revolution of the shaft 16.

A longitudinal slot 37 formed in the shaft 16 connects the slots 31 and 32 to the peripherally continuous slot or groove 34 and 35. In like manner, a longitudinally extending slot or passage 38 connects the slots or grooves 33 and 34 with the peripherally continuous slot or groove 36. There is thus formed a series of inlet passages and outlet passages.

To rotate drive the crank and valve shaft 16, a pulley 46 is keyed by a key 47 and a screw 48 to the shaft 16. The pulley 46 will be driven by a pulley belt as a portion of the accessory drive from the engine of the automotive vehicle.

In operation, the action of the rotary valving on the pump can be clearly followed upon considering the action of the valve grooves or slot through one revolution of the shaft 16, as driven by the pulley wheel 46.

If the shaft 16 is turned in the direction of the arrows as shown in the drawings, the diaphragm 1 will be raised compressing air in the upper chamber 12. However, it will be noted that the upper chamber 12 is open through the holes 43 and 45 to the segmental slot or groove 34 on the shaft 16. The groove 34 is connected to the peripherally continuous groove or groove 36 by the passage 38 which, in turn, is in communicative register with the outlet 40 at all times so the air in the upper pumping chamber 12 will be forced through 43, 45, 34 and out the opening 40.

At the same time, air in the lower pumping chamber 13 is in a vacuum state, but the lower pumping chamber 13 has an opening 42 which is open to the segmental groove 32 connected to the peripherally continuous slot or groove 35 communicating with the inlet port 39, thus allowing air to enter into the lower pumping chamber 13 to replace the vacuum.

As the crank 15 continues to rise until it is upon its dead center, the diaphragm 1 will raise and force all of the air out of the upper pumping chamber 12 and will have filled the lower pumping chamber 13. Then, as the crank 15 passes top center, the ends of the segmental slots or grooves 34 and 32 will pass the openings 45 and 42, thereby closing the same. At the same time, the segmental grooves 33 and 31 will have their open ends pass or open into the opening 41 and the end of the opening 44 corresponding to the opening 45 at the other end of the shaft 16.

As the shaft continues to turn in the direction of the arrows, the air in the upper pumping chamber 12 will become ratched and air will be sucked into that chamber through the opening 44, the groove 31 and the port 39. Thus, air in the lower pumping chamber 13 will be compressed and forced out of the opening 41 in the groove 33 which has turned to open to the hole or opening 41.

The air then passes through the slot 38 to the peripherally continuous slot or groove 36 and out through the port 40.

The registering of the open end of the segmental grooves 34 and 33 is retarded with respect to the openings 41 and 45 so that pressure will build up in the pumping chambers until it equals the back pressure in the air storage tank which may be associated with this system, or otherwise, the air going to the pumping chambers until the pressure in the chambers equaled that in the tank. In this connection, it may be understood that in an automotive organization, as herein contemplated by way of illustrative example, the port 40 may be connected by suitable piping to a storage tank or directly to an afterburner control. Where the port 39 is open to the atmosphere, or to a filter tank.

To facilitate fastening of the pump to a vertical support, an auxiliary bracket 49 secured to the lower housing 3 by screws 50 and 51 is provided. It will be understood that other shapes and types of brackets can be attached to the lower housing 3 by screws 50 and 51 for a variety of mounting requirements, as may occur in different automotive applications, for example.

It will be appreciated that the slot 43 in the upper housing 2 might permit the diaphragm 1 to raise up into the slot or groove if a rectangular plate shown at 52 were not inserted into a complemental recess provided to position the plate 55 and to hold the diaphragm 1 down tightly against the lower housing 3.

In FIGURE 5, an alternative embodiment of the present invention is illustrated wherein the top vertical projection of the yoke 5 has been replaced by a crank arm 52 which has been added. Also, the embodiment of FIGURE 5 differs from the structure already described in that the bellows 22 may be removed and a packing or O-ring 54 placed between the bearing 32 and the yoke 53, thereby cutting down the size and expense of making the pump.

Although minor modifications might be suggested by those versed in the art, it should be understood that I wish to embody within the scope of the patent warranted hereon all such modifications as reasonably and properly come within the scope of my contribution to the art.

I claim as my invention:

1. A pump comprising upper and lower housing members together forming a casing having a lower crank case and an upper pumping chamber, a diaphragm extending across said pumping chamber dividing the interior thereof into first and second pumping chambers, a slide yoke connected to said diaphragm, bearing means in said yoke for reciprocation, a crank connected to said slide yoke and extending into said crank case, and a rotary shaft extending through said crank case and connected to said crank to drive said pump upon rotation of said shaft, said shaft having plural partial grooves formed in the periphery thereof at spaced longitudinally intervals and at least some of said grooves being at different angular alignment, said casing having an inlet and an outlet, said shaft having a continuous peripheral groove formed therein for the inlet and for the outlet, said casing having openings periodically communicating said first and second pumping chambers with first and second sets of said plural partial grooves upon rotation of said shaft, and passage means formed in said shaft communicative of said first and second sets of said plural partial grooves respectively with said continuous grooves, wherein rotation of said shaft will operate said diaphragm to pump air from said inlet to said outlet with a double acting operation.

2. In a pump, a casing having an inlet and an outlet, a cylindrical bore in said casing intersecting said inlet and said outlet, a shaft rotatable in said bore having a pair of peripherally continuous grooves in respective register with said inlet and said outlet, a first pair of segmental peripheral grooves in said shaft, the opposite sides of the continuous groove on the side of the pump, a second pair of segmental peripheral grooves in said shaft on the opposite sides of the continuous groove on the outlet side of the pump, a crank arm connected to
an intermediate portion of said shaft, said casing having a pumping cavity formed therein adjacent said bore, a diaphragm extending across said pumping cavity and partitioning the chamber into first and second pumping chambers, a slide yoke slidably carried in said casing connected to said crank arm and to said diaphragm, thereby to provide said diaphragm with a double acting pumping action, passages formed in said casing extending from each pumping chamber to a corresponding segmental groove, whereby the pumping chambers are alternately communicated with said inlet and said outlet.

3. A double acting pump comprising a diaphragm, casing means forming a pumping chamber on each side of said diaphragm, an inlet and an outlet for each pumping chamber, an inlet port and an outlet port for said pump formed in said casing means, and valve means sequentially communicating said inlet and said outlet with said ports, and a common actuating means to reciprocate said diaphragm and operate said valving means, thereby to develop a double pumping action.

4. A pump comprising a casing having an inlet port and an outlet port, a cylinder formed in said casing and having a rotary shaft therein, means forming circumferentially continuous grooves between said shaft and said casing at said inlet port and at said outlet port, said shaft having segmental peripheral grooves formed therein, there being one groove on each side of each of said continuous grooves, passage means communicating each corresponding segmental groove with a corresponding adjacent pair of said segmental grooves, and a double acting fluid pumping means operatively connected to and actuated by said rotary shaft upon rotation thereof, said pumping means including separate pumping chambers each having an inlet opening and an outlet opening communicating with a corresponding segmental groove, whereupon rotation of said shaft will develop a valving action for alternately opening and closing said openings to control the double acting pumping action.

5. A pump comprising a casing having an inlet port and an outlet port, a cylinder formed in said casing and having a rotary shaft therein, means forming circumferentially continuous grooves between said shaft and said casing at said inlet port and at said outlet port, said shaft having segmental peripheral grooves formed therein, there being one groove on each side of each of said continuous grooves, passage means communicating each corresponding segmental groove with a corresponding adjacent pair of said segmental grooves, and a double acting fluid pumping means including separate pumping chambers each having an inlet opening and an outlet opening communicating with a corresponding segmental groove, whereupon rotation of said shaft will develop a valving action for alternately opening and closing said openings to control the double acting pumping action, said fluid pumping means including displacement means actuatingly driven by said shaft in synchronism with the valving action.

6. A pump comprising a casing having an inlet port and an outlet port, a cylinder formed in said casing and having a rotary shaft therein, means forming circumferentially continuous grooves between said shaft and said casing at said inlet port and at said outlet port, said shaft having segmental peripheral grooves formed therein, there being one groove on each side of each of said continuous grooves, passage means communicating each corresponding segmental groove with a corresponding adjacent pair of said segmental grooves, and a double acting fluid pumping means including separate pumping chambers each having an inlet opening and an outlet opening communicating with a corresponding segmental groove, whereupon rotation of said shaft will develop a valving action for alternately opening and closing said openings to control the double acting pumping action, said fluid pumping means comprising a diaphragm having a pumping chamber on each side thereof, a slide yoke connected to said diaphragm and a crank arm connected to said slide yoke and actuatingly driven by said shaft in synchronism with the valving action.

7. An automotive pump for delivering large quantities of air to an afterburner comprising a casing having an inlet and an outlet, a shaft in said casing having a driving portion extending outside of said casing, a pulley wheel on said driving portion adapted to be driven by the engine accessory drive, said casing having a pumping cavity formed therein, a diaphragm in said cavity partitioning the same into separate pumping chambers, a slide yoke connected to said diaphragm and having a crank connection to said shaft for reciprocating said diaphragm, passage means in said casing communicating with said pumping chambers and with said inlet and said outlet, and valve rotary means operatively actuated by said shaft in control of said passage means, thereby to develop a double pumping action upon rotation of said shaft.

8. An automotive pump for delivering large quantities of air to an afterburner, comprising a casing having an inlet and an outlet, a shaft in said casing having a driving portion extending outside of said casing, a pulley wheel on said driving portion adapted to be driven by an engine accessory drive, said casing having a pumping cavity formed therein, a diaphragm reciprocating said pumping cavity into separate pumping chambers, a slide yoke connected to said diaphragm and having a crank connection to said shaft for reciprocating said diaphragm, passage means communicating with said pumping chambers and with said inlet and said outlet, said casing having a cylindrical bore formed therein intersecting said inlet and said outlet, a shaft rotatable in said bore having a pair of peripherally continuous grooves in respective registry with said inlet and said outlet, said casing having a pair of segmental peripheral grooves in said shaft on opposite sides of said continuous grooves on the inlet side of the pump, a second pair of segmental peripheral grooves in said shaft on opposite sides of the continuous groove on the outlet side of the pump, said passage means communicating with said pumping chambers and with said inlet and said outlet including said segmental grooves whereupon rotation of said shaft will develop a valving action to control the double pumping action of the pump.

9. An automotive pump for delivering large quantities of air to an afterburner comprising a casing having an inlet and an outlet, a shaft in said casing having a driving portion extending outside of said casing, a pulley wheel on said driving portion adapted to be driven by the engine power take off, said casing having a pumping cavity formed therein and a crank case portion adjacent thereto, a diaphragm in said pumping cavity partitioning said cavity into separate pumping chambers, a slide yoke connected to said diaphragm and having a crank extending into said crank case for connection to said shaft, whereupon rotation of said shaft will reciprocate said diaphragm, passage means formed in said casing communicating with said pumping chambers and with said inlet and said outlet, and valve means operatively actuated by said shaft in control of said passage means, thereby to develop a double pumping action upon rotation of said shaft, said crank case being adapted to carry oil for splash lubrication of moving parts, and a bellows clamped between said diaphragm and said slide yoke at one end and connected to said casing at the other end, thereby to seal out oil from the pumping chamber.

10. In a pump, upper and lower housing parts having outer interengangeable edge portions and inner portions forming a casing having a hollow interior, a diaphragm having its outer periphery clamped between said edge portion of said upper and lower housing parts.
and dividing the hollow interior of the casing into upper and lower pumping chambers, clamping means in said casing and clamping the inner edges of the diaphragm, bearing means in said casing, a slide yoke supported for reciprocation in said bearing means and connected to said clamping means, thereby to reciprocate said diaphragm, and valve controlled passage means in said housing parts communicating with said upper and lower pumping chambers to develop a double pumping action upon operation of said diaphragm, said bearing means comprising a bearing in said upper part and a bearing sleeve in said lower part, the slide yoke having a peripheral bearing surface slidably engaging the bearing sleeve in the lower part on one side of the diaphragm and a shaft extension having a bearing surface formed therein engaging the bearing in the upper part on the opposite side of the diaphragm.

11. In a pump as defined in claim 10, said diaphragm having an integral bead on the outer and inner peripheries thereof spaced inwardly of the corresponding edge, said casing and said plate members being correspondingly recessed to receive said beads, thereby to center and anchor the diaphragm.

12. In a pump as defined in claim 10, a sealing means between said lower housing member and said slidable yoke, said lower housing having a crank case, said rotatable means in said crank case including a crank arm connected to said yoke to reciprocate said slidable yoke, said sealing means operating to seal out oil from the lower pumping chamber.

13. In a pump as defined in claim 12, said sealing means comprising a bellows connected at one end to said clamping means and connected at its opposite end to said lower housing part.

References Cited in the file of this patent

UNITED STATES PATENTS

<table>
<thead>
<tr>
<th>Patent</th>
<th>Inventor</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>677,474</td>
<td>Russell</td>
<td>July 2, 1901</td>
</tr>
<tr>
<td>781,678</td>
<td>Richwood</td>
<td>Feb. 7, 1905</td>
</tr>
<tr>
<td>1,093,014</td>
<td>Sleeper</td>
<td>Apr. 14, 1914</td>
</tr>
<tr>
<td>1,204,939</td>
<td>Duncan</td>
<td>Nov. 14, 1916</td>
</tr>
<tr>
<td>1,593,838</td>
<td>Michelsen</td>
<td>July 27, 1926</td>
</tr>
<tr>
<td>1,747,338</td>
<td>Vogt</td>
<td>Feb. 18, 1930</td>
</tr>
<tr>
<td>2,013,484</td>
<td>Alvak</td>
<td>Sept. 3, 1935</td>
</tr>
<tr>
<td>2,169,456</td>
<td>Wahlmark</td>
<td>Aug. 15, 1939</td>
</tr>
<tr>
<td>2,189,526</td>
<td>Babitch</td>
<td>Feb. 6, 1940</td>
</tr>
<tr>
<td>2,252,757</td>
<td>Carlson</td>
<td>Aug. 19, 1941</td>
</tr>
<tr>
<td>2,509,227</td>
<td>Gordy</td>
<td>May 30, 1950</td>
</tr>
<tr>
<td>2,633,552</td>
<td>Geeraert</td>
<td>Sept. 29, 1953</td>
</tr>
<tr>
<td>2,764,097</td>
<td>Browne</td>
<td>Sept. 25, 1956</td>
</tr>
<tr>
<td>2,819,013</td>
<td>Paasche</td>
<td>Jan. 7, 1958</td>
</tr>
<tr>
<td>3,006,535</td>
<td>White</td>
<td>Oct. 31, 1961</td>
</tr>
</tbody>
</table>

FOREIGN PATENTS

<table>
<thead>
<tr>
<th>Patent</th>
<th>Country</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>8,704</td>
<td>France</td>
<td>Oct. 1961</td>
</tr>
<tr>
<td>281,847</td>
<td>Switzerland</td>
<td>July 1, 1952</td>
</tr>
</tbody>
</table>