

March 26, 1968

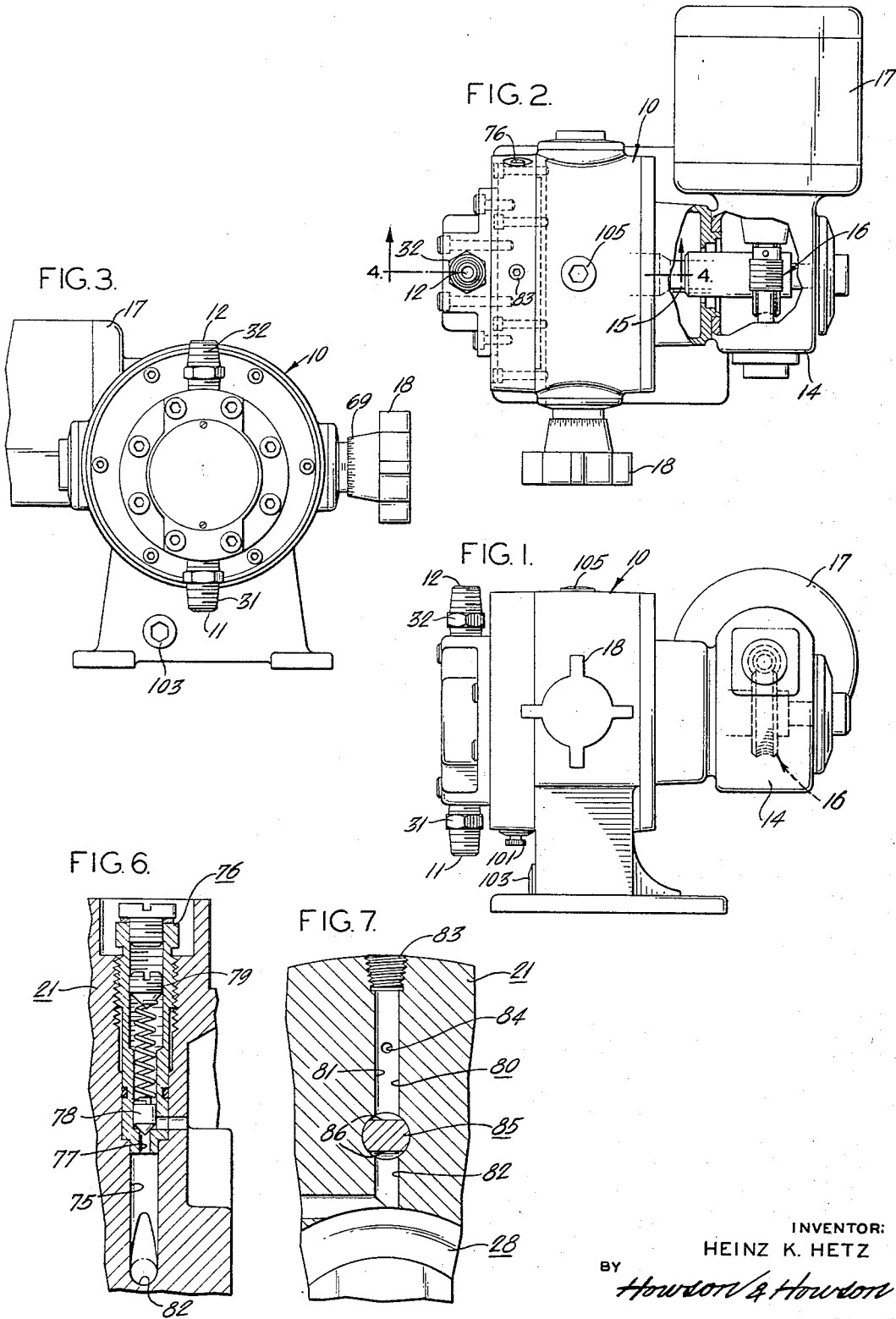
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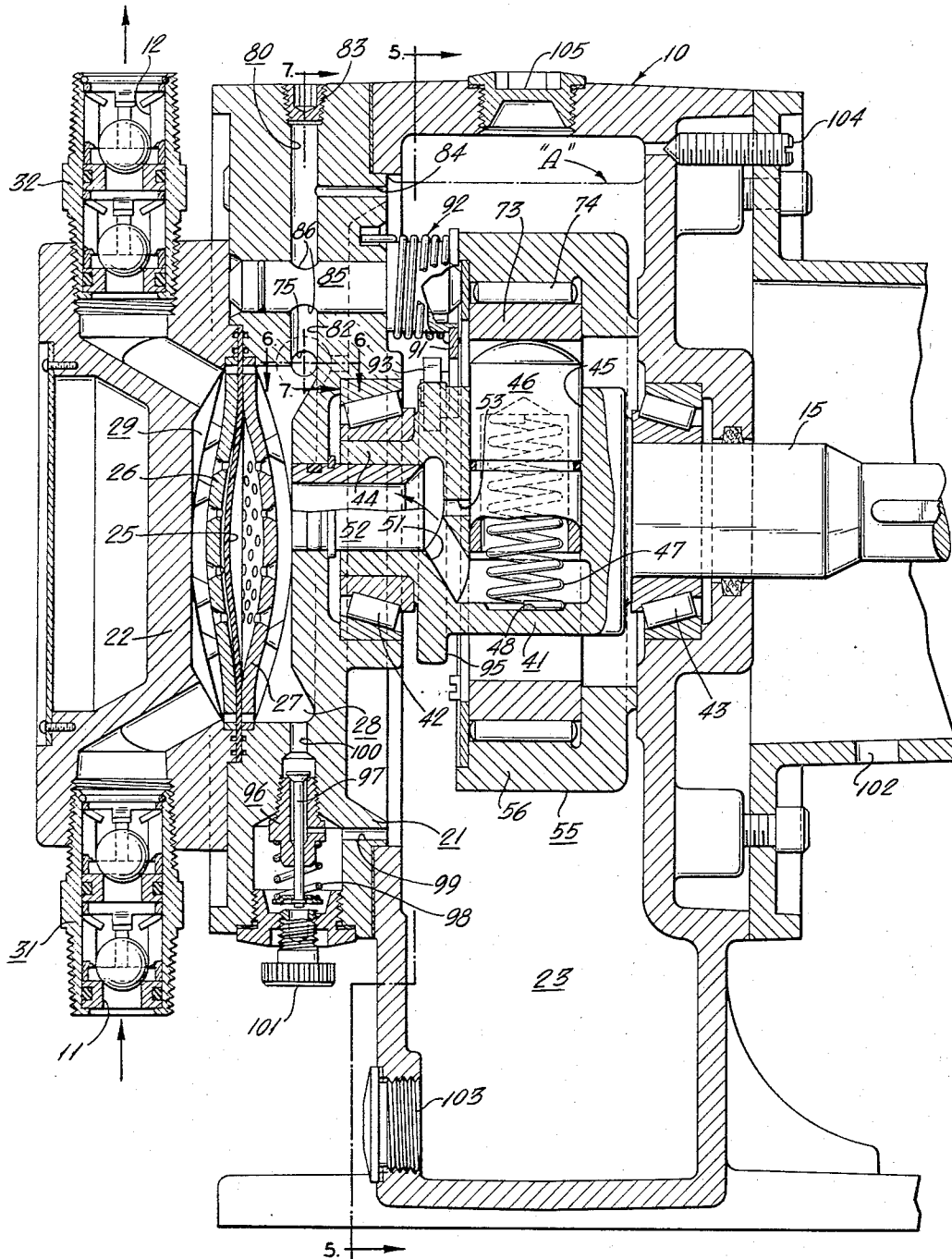
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FIG. 4.



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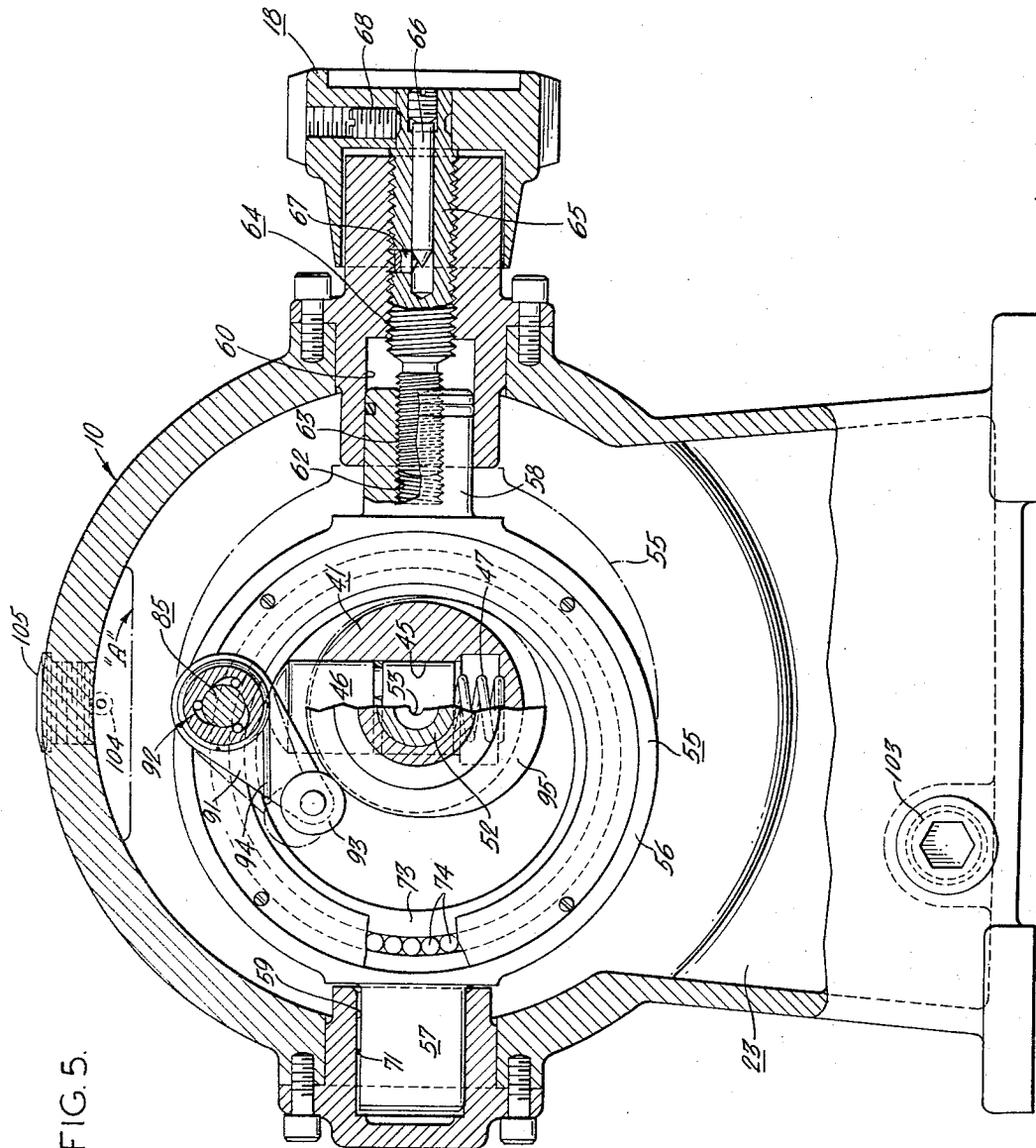
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The present invention relates to a rotary pump, and has particular application to an orbiting piston pump for supplying a pulsating pumping fluid to the pumping chamber of a diaphragm pump.

In the operation of a diaphragm pump wherein the pumping liquid is repeatedly surged into the pumping chamber of the diaphragm pump, there is a tendency for the entrapped air to accumulate in the pumping chamber and to produce a pocket of air in the pumping chamber which detracts from the operating efficiency of the diaphragm pump. Furthermore, in pumps of this character, the adjustment to provide a variation in the throughput of working fluid in the diaphragm pump either entails a shut-down of the pump and an adjustment of the operating mechanisms or provides within the pump complicated adjusting linkages which reduce the accuracy of adjustment and introduce moving parts which are subject to frictional wear with the resultant reduction in mechanical efficiency and the need for periodic shut-downs for maintenance.

With the foregoing in mind, the present invention provides a novel pump arrangement having improved means for venting air or other entrapped gaseous fluid to prevent the formation of air or gas pockets within the pumping chamber of the diaphragm pump.

The present invention also provides an improved pump wherein the stroke of the pumping element may be accurately controlled without interrupting operation of the pump.

Another object of the present invention is to provide a novel pump of the diaphragm type wherein the pumping chamber is supplied with a pulsating supply of pumping liquid from a rotary pump having a reciprocating piston mounted within a radial recess in the rotor, the recess being positioned adjacent the pumping chamber of the diaphragm pump to reduce to a minimum loss occasioned by elongated pumping fluid conduits.

More specifically, the present invention provides an improved adjustment mechanism of this type wherein the adjustment is linear.

The present invention also provides a pump of the stated type wherein the rotor is mounted in a closed casing containing pumping fluid wherein any solid particles entrained in the pumping fluid may settle to the bottom to avoid interference with the rotor operation and entrapped air will rise to the top where it may be vented to the atmosphere.

Still a further object of the present invention is to provide a novel pump of the above type which is relatively compact, having a short overall length and a very short distance between bearings supporting the rotor. The construction of the pump of the present invention permits the orbiting piston and diaphragm to be mounted in extremely close relation to provide a sturdy, compact unit.

All of the objects of the invention are more fully set forth hereinafter with reference to the accompanying drawings wherein:

FIG. 1 is a view in side elevation of a pump made in accordance with the present invention;

FIG. 2 is a plan view of the pump shown in FIG. 1;

FIG. 3 is a fragmentary view in end elevation of the pump;

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FIG. 4 is an enlarged sectional view taken on the line 4—4 of FIG. 2;

FIGS. 5, 6 and 7 are sectional views taken on the lines 5—5, 6—6 and 7—7, respectively, of FIG. 4.

Referring now to the drawing, the illustrated pump comprises a casing 10 having at one end a work fluid inlet 11 and a work fluid outlet 12. At the other end, a gear case housing 14 receives a rotor shaft 15 and contains gear connections 16 to a drive motor 17. An adjusting member is provided at 18 on the front of the casing 10.

Internally, the casing 10 has a wall member 21 which divides the casing into a diaphragm housing 22 and a rotor housing or chamber 23. A diaphragm 25 is positioned between diaphragm plates 26 and 27 in the diaphragm housing to divide the housing into a pumping chamber 28 and a work chamber 29. The inlet 11 is connected to the work chamber 29 through a non-return valve 31 and the outlet 12 is connected to the work chamber 29 through a non-return valve 32. The valves 31 and 32 operate upon flexure of the diaphragm 25 to effect flow of work fluid upwardly through the work chamber 29.

In order to effect flexure of the diaphragm 25, means is provided to flow surges of pumping fluid into and out of the pumping chamber 28. To this end, a rotor 41 is mounted in the rotor housing 23, for example, by tapered roller bearings 42 and 43 on an inner rotor shaft 44 and the outer rotor shaft 15, respectively. The rotor 41 has a radial recess 45 therein which slidably mounts a piston 46. The piston 46 is biased outwardly by a spring 47 which seats in the bottom of the recess as indicated at 48. The bottom of the recess 45 communicates with the pumping chamber 28 through a port 51 and a hollow transfer member 52. A central venting aperture is provided between the interior of the member 52 and the center of the rotor recess as indicated at 53 to permit the escape of air from the center of the recess 45.

In order to obtain a pumping action as the rotor is rotated by the drive motor 17, an eccentric guide means 55 surrounds the rotor in engagement with the exposed end of the piston 46. The guide means is adjustably mounted in the casing 10 to control the throw of the piston 46 and to this end, the guide means 55 comprises an outer control member 56 having outwardly projecting stub shafts 57 and 58, respectively, engaging in bores 59 and 60 in the casing 10.

As shown in FIG. 5, adjusting means is provided to displace the stub shafts 57 and 58 in their bores to control the eccentricity of the control member 56 to the rotor 41. To this end, the stub shaft 58 is provided with an internally threaded socket 62 adapted to threadably engage an end portion 63 on an adjusting screw 64. The body 65 of the adjusting screw 64 is threaded into the casing and may be locked in place by a locking pin 66 cooperating with a locking slug 67 in the screw body 65. The thread pitch of the end portion 63 is less than thread pitch of the body portion so that the axial movement of the adjustment screw is larger than the travel of the control member, for example, 1" axial movement of the adjustment screw will result in a 1/2 in. travel of the control member, thus providing improved resolution at the micrometer dial readout. The adjusting knob 18 is fixed to the screw 64 by a set screw 68 and index markings are provided at 69 (see FIGS. 2 and 3) to indicate the position of the control member in the rotor housing 23. In order to prevent hydraulic lock of the shaft 57 in the recess 59, a flat is provided on the shaft 57 as indicated at 71 to allow entrapped fluid to escape from the recess 59. This adjustment of the control member provides for a linear relation between adjusting movement of the adjusting knob 18 and adjustment of the throw of the

piston 46 to enable as closely as possible a linear regulation of the through-put of the diaphragm pump. There is minimum lost motion in the adjustment, and the adjustment may be performed without arresting operation of the pump.

In order to reduce friction and the resultant wear, means is provided to enable rolling engagement of the piston end against the guide. To this end, a liner or reaction ring 73 is mounted for relative rotation within the control member 56 by means of rollers 74. Thus, the liner 73 may rotate with the rotor 41 to eliminate sliding friction between the piston 46 and the guide means 55. The control member 56 and liner 73 function as a roller bearing to eliminate sliding friction.

In the operation of the pump, the rotor housing 23 is filled with pumping liquid, for example, to the level indicated at A in FIGS. 4 and 5. As the rotor is rotated by the motor 17, the eccentricity of the guide means 55 displaces the piston within the radial recess 45. Inward displacement of the piston 46 pumps the pumping fluid from the bottom of the recess 45 through the port 51 and discharge outlet in the member 52 into the pumping chamber 28 thereby flexing the diaphragm 25 outwardly toward the outer diaphragm plate 26. Flexing the diaphragm outwardly forces working liquid in the work chamber 29 out through the valve 32 into the outlet 12. As the rotor 41 continues to rotate, the spring 47 displaces the piston 46 outwardly thereby drawing pumping liquid from the chamber 28 through the member 52 and port 51 into the bottom of the recess 45. Withdrawal of the pumping liquid from the chamber 28 flexes the diaphragm 25 toward the inner diaphragm plate 27 drawing working liquid into the chamber 29 from the inlet 11 through the inlet valve 31.

Air or other gaseous fluid in the pumping liquid which might otherwise accumulate behind the piston 46 are free to escape into the discharge outlet 52 through the venting aperture 53 and into the pumping chamber 28. Bubbles in the pumping chamber 28 rise to the top, and in accordance with the invention, means is provided to vent the accumulated gaseous fluid from the pumping chamber to thereby prevent deterioration of the pumping action. As shown in FIGS. 4, 5 and 7, vent means is provided to periodically remove a predetermined volume of fluid from the top of the pumping chamber 28 and to replace a like volume of pumping liquid. To this end, a vertical passage 80 is provided in the wall 21 at the top of the pumping chamber 28. The passage extends upwardly through the wall and is closed at its uppermost end by a plug 83. A connecting passage 84 connects the passage 80 with the rotor housing 23 adjacent the upper end of the latter.

For effective operation, the pumping chamber 28 must be continuously closed and to prevent escape of pumping fluid from the pumping chamber 28 during normal operation of the pump, the passage 80 is closed by a venting shaft 85 which divides the passages 80 into an upper branch 81 and a lower branch 82. The venting shaft 85 has pockets 86 in registry with the vertical passage 82 and means is provided to displace the shaft 85 periodically to cause the pockets to rotate from a position in registry with the upper branch 81 of the passage. Thus, during the operation of the pump, the pocket 86 which is in registry with the lower branch 82, is filled with fluid. If bubbles have accumulated in the pumping chamber 28, the bubbles will travel into the lower branch 82 and into the pockets 86 displacing any pumping fluid which may be contained therein. When the shaft is rotated, the fluid in the pocket, whether pumping fluid or gaseous fluid from the bubbles, is carried into the upper branch 81 of the passageway. At the same time, pumping fluid which is accumulated in the upper branch 81 is carried by the opposite pocket back to the pumping chamber 28. The gaseous fluid transferred to the upper branch 81 accumulates at the top of the passageway 80 and when

the level of the pumping fluid in the upper branch 81 falls below the level of the connecting passage 84, additional pumping fluid is free to enter the passage through the passage 84 from the rotor chamber 23. Thus, the upper branch 81 is continuously supplied with pumping fluid to replace the gaseous and/or pumping fluid removed from the lower branch 82.

The shaft 85 is rotated step by step by the rotation of the rotor. To accomplish this, a crank 91 is mounted on the inner end of the shaft 85 through a one-way clutch 92. The free end of the crank 91 has a follower roller 93 thereon which is biased by a spring 94 against a cam ring 95 formed integrally with the rotor 41. In the present instance, the cam ring 95 has a single lobe thereon which operates during each revolution of the rotor to oscillate the follower 93 and therefore the lever 91 an angular distance of about 15° so as to index the shaft 85 a similar amount. Thus, the shaft 85 is rotated in steps as the rotor rotates. In the present instance, the shaft is rotated one full turn for every 24 turns of the rotor 55 of the rotary pump.

Suitable pressure relief means is provided to prevent overloading of the pump. To this end, a relief passageway 75 is provided in the wall member 21, in the present instance, in horizontal alignment with the lower end of the vertical passageway 80 in the chamber 28. The relief passageway 75 terminates in a relief valve assembly 76 having a pressure relief port 77 which is normally closed by a spring-loaded valve element 78. The loading of the valve element 78 is adjustable by means of an adjusting screw 79, as shown in FIG. 6. The relief valve assembly 76 is threaded into the wall member 21 so as to enable removal of the valve assembly 76 for rapid venting of the pumping chamber, for example, during initial fill of the pump with pumping fluid.

In the event of loss of pressure fluid from the pumping chamber 28, make-up fluid is automatically supplied from the rotor chamber 23. To this end, a make-up inlet 100 is provided in the bottom of the pumping chamber which is normally closed by a check valve 96. The check valve includes a valve element 97 which is normally biased closed by a spring 98. When the pressure in the pumping chamber 28 is reduced sufficiently to allow the pressure in the rotor chamber 23 to overcome the bias of the spring 98, the valve element 97 opens the valve to admit pumping fluid from the rotor chamber 23 through the port 99. An operator 101 is provided to relieve the pressure of the spring 98 in order to permit opening of the valve 97, for example, during initial fill and during draining to allow rapid flow of pumping fluid between the rotor chamber 23 and pumping chamber 28.

In order to provide for draining of the pumping fluid, a drain plug is provided in the rotor chamber 23 at the bottom thereof as indicated at 103 so that the pumping fluid and any accumulated sludge at the bottom of the rotor chamber may be discharged. During normal operation of the pump, the chamber is vented by releasing a vent stop 104 at the top of the chamber to permit expansion and contraction of the pumping liquid. Air flow during expansion or contraction of the pumping liquid occurs through a vent hole 102 in the bottom of the gear case 14. During shipping of the pump, the vent stop 104 is in the closed position to prevent loss of liquid. A quick fill plug is also provided at the top of the chamber as indicated at 105.

The drawings illustrate a rotary pump having a single radial recess and piston in the rotor, but is apparent that the rotor may be elongated to accommodate a plurality of pistons working together or in opposition to one another as desired. Furthermore, the illustrated embodiment of the invention utilizes an axial discharge conduit from the rotor recess and it may be desired to discharge the fluid radially into a pressure chamber in fluid communication with the pumping chamber without adversely

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affecting the "stiffness" provided by the juxtaposition of the rotor with the pumping chamber.

While a particular embodiment of the invention has been illustrated and described herein, other changes and modifications may be made therein and thereto within the scope of the following claims.

I claim:

1. In a pump assembly comprising a diaphragm pump having a pumping chamber, a work chamber, a valve-controlled inlet and valve-controlled outlet for said work chamber, and a pumping port for admitting a pulsating liquid pumping fluid to said pumping chamber to flex the diaphragm and effect pumping of work fluid through said work chamber; and a rotary pump for supplying a pulsating pumping fluid to said pumping port; the improvement wherein said pumping chamber includes means to vent gaseous fluid from said pumping chamber comprising a passage in the top of the pumping chamber, a shaft intersecting said passage to separate the passage into a lower branch and an upper branch, said shaft including pocket means operable upon displacement of said shaft between first and second positions to alternatively register respectively with the top of said lower branch and the bottom of said upper branch, means to introduce liquid pumping fluid into said upper branch, and means to displace said shaft successively between said first position wherein said pocket receives a predetermined volume of fluid from the top of said lower branch, and said second position wherein said pocket receives said predetermined volume of liquid pumping fluid from the bottom of said upper branch, whereby any gaseous fluid in said pumping chamber is transferred to said upper branch upon displacement of said shaft from said first position to said second position and pumping fluid is transferred from said upper branch to said chamber upon displacement of said shaft from said second position to said first position.

2. A pump assembly according to claim 1 wherein said means to displace the shaft comprises a follower carried by said shaft and a cam ring carried by said rotary pump and engaging said follower, whereby said shaft is displaced alternately between said first and second positions upon rotation of said rotary pump.

3. A pump assembly according to claim 1 wherein said upper and lower branches are in vertical alignment and said shaft is mounted for rotation intermediate said branches, said displacing means being operable to rotate said shaft in steps between said first and second positions.

4. A pump assembly according to claim 3 wherein said displacing means includes a follower carried by said shaft, a one-way clutch interconnecting said follower to said shaft, and a cam carried by said rotary pump to engage and oscillate said follower to thereby rotate said shaft in steps.

5. A pump assembly according to claim 1 wherein said rotary pump comprises a rotor housing adjacent said pumping chamber, a rotor mounted for rotation in said housing and having a substantially radial recess formed therein, a piston mounted for reciprocating movement within said recess, an adjustable guide within said housing surrounding said rotor in engagement with the outer end of said piston to control reciprocating movement of said piston upon relative rotation of said rotor and said guide means, and a fluid discharge port connected to said recess at its inner end and connected to said pumping port to conduct said pulsating liquid pumping fluid to said pumping chamber upon reciprocation of said piston, said rotor housing adapted to be filled with pumping fluid, said means to introduce pumping fluid into said upper branch comprising a connecting passage intermediate said upper branch and said rotor housing.

6. A pump assembly according to claim 5 wherein said guide means comprises a control member mounted in said housing eccentric to said rotor, and a reaction ring mounted for free rotation interiorly of said control member and engaging the outer end of said rotor piston.

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7. A pump assembly according to claim 6 including means to adjust the eccentricity of said control member from the outside of the housing including an adjusting screw threaded in said housing and engaging said control member whereby the eccentricity of said guide means may be adjusted during rotation of said rotary pump to thereby control the pulsations of said pumping fluid and thus the through-put of the diaphragm pump.

8. A pump assembly according to claim 7 wherein said adjusting screw is also threaded into said control member with a different pitch from the threading in the housing to thereby provide a fine adjustment which is free from substantial play.

9. In a pump assembly comprising a housing, a rotor mounted within said housing, a radial recess formed in said rotor, a piston mounted for reciprocating movement within said radial recess, an adjustable guide within said housing engaging said piston, and surrounding said rotor to control reciprocating movement of said piston upon relative rotation between said rotor and said guide, drive means to cause relative rotation between said rotor and said guide, adjusting means accessible from the exterior of said housing to adjust the position of said guide relative to said rotor, a pumping chamber remote from said rotor, a fluid discharge outlet in said rotor in fluid communication with said radial recess, said discharge outlet terminating in fluid communication with said pumping chamber, said housing being completely filled with a pumping fluid, and vent means to remove a predetermined volume of pumping and/or gaseous fluid from the uppermost portion of said pumping chamber at predetermined intervals during the pumping operation and discharge the same into the pumping fluid in said housing, said vent means operable to replace said predetermined volume of pumping and/or gaseous fluid removed from said pumping chamber with an equal volume of pumping fluid.

10. Apparatus in accordance with claim 9 wherein said guide means includes a control member interconnected with said adjusting means, and a reaction ring mounted for free rotation within said control member and engaging said piston, said control member being adjustable in a direction normal to the axis of said rotor from a first limit position concentric with the axis of said rotor to a second limit position offset from the axis of said rotor.

11. Apparatus in accordance with claim 9 wherein a wall member separates the upper end of said pumping chamber from the fluid within said housing and said vent means includes a rotatable shaft extending through said wall member, at least two pockets formed in the peripheral surface of said rotatable shaft, a lower branch passage in said wall member extending from said rotatable shaft to the uppermost portion of said pumping chamber, an upper branch passage in said wall member extending from said rotatable shaft and connected to the pumping fluid in said housing, and drive means for said shaft operable upon relative rotation between said rotor and said guide to cause rotation of said shaft to move a pocket in said shaft from a position in fluid communication with said lower branch to a position in fluid communication with said upper branch and simultaneously therewith move the second pocket from a position in fluid communication with said upper branch to a position in fluid communication with said lower branch.

12. In a pump assembly comprising a housing, a rotor mounted within said housing, a radial recess formed in said rotor, a piston mounted for reciprocating movement within said radial recess, an adjustable guide within said housing engaging said piston, and surrounding said rotor to control reciprocating movement of said piston upon relative rotation between said rotor and said guide, drive means to cause relative rotation between said rotor and said guide, a pumping chamber remote from said rotor, a fluid discharge outlet in said rotor in fluid communication with said radial recess, said discharge outlet ter-

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minating in fluid communication with said pumping chamber, said housing being completely filled with a pumping fluid, a control member, means adjustably mounting said control member in said housing for movement in a direction normal to the axis of said rotor, and means interconnecting said control member with said adjustable guide to move said adjustable guide from a first limit position concentric with the axis of said rotor to a second limit position offset from the axis of said rotor upon adjusting movement of said control member.

13. In the pumping chamber of a pump assembly, means to vent gaseous fluid from said pumping chamber comprising a passage in the top of the pumping chamber, a shaft intersecting said passage to separate the passage into a lower branch and an upper branch, said shaft including pocket means operable upon displacement of said shaft between first and second positions to alternatively register respectively with the top of said lower branch and the bottom of said upper branch, means to introduce liquid pumping fluid into said upper branch, and means

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to displace said shaft successively between said first position wherein said pocket receives a predetermined volume of fluid from the top of said lower branch, and said second position wherein said pocket receives said predetermined volume of liquid pumping fluid from the bottom of said upper branch, whereby any gaseous fluid in said pumping chamber is transferred to said upper branch upon displacement of said shaft from said first position to said second position and pumping fluid is transferred from said upper branch to said chamber upon displacement of said shaft from said second position to said first position.

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