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(71) Applicant: **Wilden Pump & Engineering Co., 22069 Van Buren Street, Colton California (US)**

(72) Inventor: **Wilden, James K., 11727 Pendleton, Yucaipa California (US)**
Inventor: **Tuck, Alan D., Jr., 2370 North Euclid Avenue, Upland, California (US)**

(74) Representative: **Bardo, Julian Eason, Abel & Imray Northumberland House 303-306 High Holborn, London, WC1V 7LH (GB)**

(54) **Air driven diaphragm pump and actuator valve.**

(57) A diaphragm pump has opposed pump cavities (29, 31), a pump drive assembly (10, 12, 14) between said cavities (29, 31) forming an inner wall of each of said cavities (29, 31), pump chamber housings (28, 30) meeting with said pump drive assembly (10, 12, 14) to form the outer wall of each of said cavities (29, 31), an inlet manifold (128) extending to and in communication with each of said cavities (29, 31) and an outlet manifold (136) extending to and in communication with each of said cavities (29, 31), said inlet and outlet manifolds (128, 136) being diametrically opposed.

Means (148) forcibly drawing said manifolds (128, 136) toward one another are provided and said manifolds (128, 136) and said pump chamber housings (28, 30) include mating surfaces there between lying in planes at an acute angle to the line of force drawing said manifolds toward one another, said manifold mating surfaces each being outwardly of each associated pump chamber housing mating surface.

The actuator valve comprises a valve piston (48), a control rod (15) fixed to reciprocate with the air driven reciprocating device, and a housing (36) having a cylinder (50) closed at each end and enclosing said valve piston (48), a passageway through which said control rod (15) extends, an air inlet (52) to said cylinder (50) spaced from the ends of said cylinder (50), valve piston vent passages (82, 84) extending from the ends of said cylinder (50) to said passageway, and control rod vent passages (112, 114) extending from said passageway to atmosphere, said valve piston (48) cooperating with said housing (36) to include means (78, 80) for directing incoming air to the ends of said valve piston (48) and means (58, 60) for selectively directing incoming air to and exhausting outgoing air from the air driven reciprocating device.

There is an axial passage (110) in said control rod (15) positioned between said valve piston vent passages (82, 84) to vent selectively each of said valve piston vent passages (82, 84) to said control rod vent passages (112. 114).

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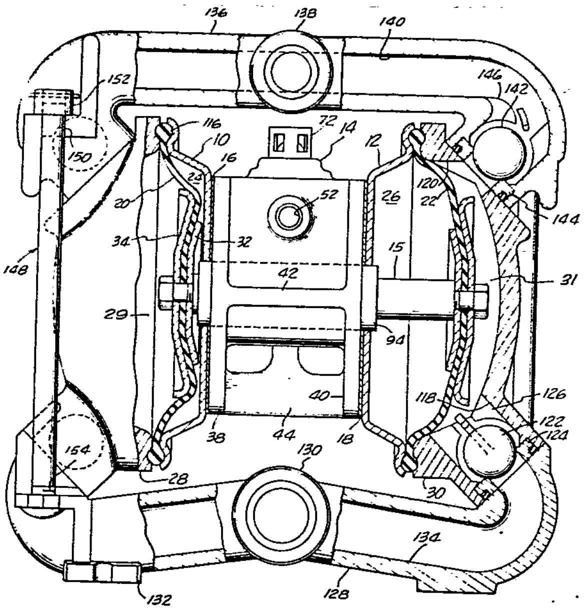
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DESCRIPTION

AIR DRIVEN DIAPHRAGM PUMP AND ACTUATOR VALVE

Technical Field

The present invention is directed to air driven diaphragm pumps.

Background of the Invention

Air driven diaphragm pumps have found great utility in construction and industrial uses. The durable and reliable nature of these devices along with their ability to handle a wide variety of substances have made these pumps mandatory equipment in many applications. In many construction and maintenance operations, the portability of these devices is also a major advantage.

In pumps of this nature, the least durable part of the pump is most often the diaphragm or diaphragms used to alternately expand and contract the pumping chamber. Such diaphragms are expected to survive a high number of flexure cycles and a significant amount of abrasion due to the environment in which they are to operate. These conditions have been found to result in the diaphragms becoming the most frequently replaced components in such pumps.

In spite of the need to periodically replace diaphragms in such devices, the diaphragms are located by necessity in positions where the major portion of the pump must be disassembled to effect their replacement. The outer pump cavity housings must naturally be removed. Furthermore, the inlet and outlet manifolding associated with those outer housings also must be detached. Heretofore, clamp bands have been employed to hold the diaphragm chamber housings together; and separate attachment mechanisms have been used to secure the manifolds. To provide repeated easy access to the diaphragm, a substantial number of bolts, clamp bands and associated fasteners have been required. Naturally, with each additional component, the pump gains in weight, cost and complexity. At the same time, the difficulty of disassembly and reassembly increases and the possibility of error becomes greater. Thus, it has long been a goal of the pump manufacturers to reduce the number of components and potential trouble spots associated with such pumps.

The foregoing difficulty is greatly aggravated in certain industries and uses where frequent dismantling is required. In brewing, all system components handling yeast or mixtures containing yeast, including pumps, must be broken down daily for cleaning. In pumping certain substances, it may also be necessary to frequently clean the pump chambers to prevent product build up and the like. Therefore, there are many situations where the pumps must be disassembled far more frequently than would be required to replace a diaphragm which has failed. Naturally, the possibilities for error are greatly increased with such frequent dismantling.

Actuator valves for such pumps and other such reciprocating pneumatically driven devices have been developed which employ a pilot valve or rod responsive to the position of the reciprocating element of the device and a pneumatically controlled valve piston responsive to the pilot rod position. The valve piston in turn controls the incoming flow of pressurized air to provide an alternating flow to the reciprocating element. This alternating flow forces the element to stroke back and forth thereby performing work and driving the pilot rod. Such actuator valves thus convert a relatively steady source of pressurized air into an alternating flow without need for any outside timing or control system. The source air pressure alone drives the valve as well as the working device.

One such actuator valve used primarily on air driven diaphragm pumps is disclosed in U.S. Patent No. 3,071,118, the disclosure of which is incorporated herein by reference. This pump system has included air driven diaphragms positioned on either side of an actuator valve in an arrangement substantially identical, outwardly of the actuator valve and pilot or control rod, to the pump shown in Figure 1 herein. In the earlier actuator valves employed with these pumps, the valve piston has been oriented vertically and the pilot rod has included two axial passages for selectively venting the appropriate ends of the chamber within which the valve piston is to operate. Vents for the axial passages have been positioned outwardly of the valve piston vents along the passageway through which the control rod extends. In this way each axial passage on the control rod would vent only one end of the cylinder within which the valve piston operates through movement of the control rod inwardly until the axial passage becomes exposed to a valve piston vent. Thus, each axial passage must cross the O-ring seals separating the air cavities of the reciprocating device from the vent passages through the actuator valve housing.

Summary of the Invention

The present invention is directed to a new assembly for air driven diaphragm pumps. The basic pump configuration has been retained with a central actuator valve, opposed pump cavities with inner and outer pump chamber housings and diametrically positioned inlet and outlet manifolds which extend to each of the opposed pump cavities. The present invention has avoided the use of clamp bands for holding the housings together around the positioned diaphragms and the fasteners required to attach the inlet and outlet manifolds to the pump body. Instead, mechanisms are employed to forcibly draw the manifolds toward one another while the mating surfaces between the manifolds and the pump chamber housings are at angles such that the drawing force on the manifolds acts to compress the total assembly together. In this way, simple tie rods between the manifolds act to hold all of the pump components in place. Thus weight, complexity and the chance of errors in disassembly and reassembly all are reduced. All of these effects are very advantageous to the utility of such devices.

To further improve the utility of the assembly mechanism, the tie rods include hand tightened nuts and carriage bolt heads positioned in slots in the diametrically opposed manifolds. Because of the O-ring type structure of the sealing rim of the diaphragms, it is necessary to create heavy sealing pressures. As pumping pressures within the pump cavities increase, the rims of the diaphragms are forced into greater sealing engagement with the pump housing. Consequently, hand tightening has been found to be sufficient. The slotted nature of the manifold attachments makes total unthreading unnecessary for disassembly. The carriage bolt heads in association with the slots make holding of the head unnecessary during assembly with the hand tightened nuts.

The present invention is also directed to an improved actuator valve having a control rod and vent passages designed to allow the central portions of the control rod passageway to be isolated from the air chambers of the reciprocating device. This is accomplished py employing a single axial passage cut into the control rod and using vents for the control rod which are located between the vent passages for the valve piston. This control rod and vent arrangement isolates the central portions of the control rod passageway because the axial passage cut into the control rod does not traverse the outermost O-ring during normal operation. In this way, a continuous seal is maintained against the reciprocating control rod.

By not having the axial passage move past the outermost O-ring, air from the air chamber of the working device cannot pass to exhaust along the control rod at any time during the operation of the device. This is advantageous in the use of diaphragm pumps because the diaphragms are necessarily made of flexible material and tend to wear out faster than the remaining parts of the device. When these diaphragms fail, they develop cracks through which the material being pumped can pass. As much of the material being pumped in practical applications of these pumps is abrasive or corrosive, adverse effects are experienced by the actuator valve when this material is able to reach the internal portions of the actuator valve. Such a condition has been avoided by the total sealing of the control rod passageway in the present invention.

Another advantage of the present invention is the avoidance of the compressed air itself escaping across the seals in the control rod passageway, a condition known as blow-by. The axial passage of the control rod does not cross the outermost seal in the present device and the compressed air in the adjacent air chamber is not able to reach the exhaust passage. Thus, there is no direct blow-by in the device and the air actually needed to fill the air chambers to drive the reciprocating device and to shift the valve piston is substantially all that is used.

The lack of blow-by becomes even more important when the reciprocating device carries a load approaching the stall point. With such a pneumatic device, the available power is limited to the pressure of the compressed air. If blow-by is experienced, the available power is reduced by these losses and stall can occur.

The use of a single axial passage on the control rod and the new vent passages have created a side benefit as well. The O-ring seals, which must be periodically replaced, are near the ends of the control rod passageway and can be easily reached in the present embodiment. Also, this new mechanism reduces machining costs and machine complexity.

Accordingly, it is an object of the present invention to provide an improved structure and actuator valve for an air driven diaphragm pump. Further objects and advantages will appear hereinafter.

Brief Description of the Drawings

Figure 1 is an elevation of a pump of the present invention with portions cut away for clarity.

Figure 2 is a side view of a pump of the present invention.

Figure 3 is a cross-sectional elevation of the actuator valve of the present invention shown in assembly with the diaphragms of an air driven diaphragm pump.

Figure 4 is a cross-sectional view taken along line 4-4 of Figure 3.

Figure 5 is a cross-sectional view taken along line 5-5 of Figure 4.

Figure 6 is a cross-sectional view taken along lines 6-6 of Figure 4.

Figure 7 is a cross-sectional view taken along lines 7-7 of Figure 5.

Figure 8 is a cross-sectional view taken along line 8-8 of Figure 7 with a portion of the control rod bushing broken out for clarity.

Detailed Description of the Preferred Embodiment

Turning in detail to the drawings, an air driven diaphragm pump is illustrated. The pump includes a central pump drive assembly consisting of two drive chamber housings 10 and 12 and an actuator valve 14 positioned between the drive chamber housings 10 and 12. Extending from the actuator valve 14 through the drive chamber housings 10 and 12 is a control rod 15. Compressed air is alternately introduced to either side of the pump drive assembly through the actuator valve 14 as determined by the position of the control rod 15. The operation of the actuator valve is disclosed in part in United States Letters Patent No. 3,017,118, the disclosure of which is incorporated herein by reference.

An overview of the operation and elements of the pump may be best viewed from Fig. 1. Drive chamber housings 10 and 12 abut the sides of the actuator valve 14 with appropriate gaskets 16 and 18 therebetween. Circular diaphragms 20 and 22 are associated with the drive chamber housings 10 and 12 to form air chambers 24 and 26. Outwardly of the diaphragms 20 and 22 are pump chamber housings 28 and 30 defining pump chambers 29 and 31. Piston assemblies are located about the center of each of the diaphragms 20 and 22 and each include an inner plate 32 and an outer plate 34 between which the diaphragms 20 and 22 are sandwiched. The inner plate 32 and outer plate 34 of the piston assemblies is associated with the control rod 15 of the actuator valve 14 as can best be seen in Figure 3.

In the context of the air driven diaphragm pump illustrated in Figure 3, the actuator valve 14 provides a source of alternating pressurized air and exhaust to each of the air chambers 24 and 26. The diaphragms move as a unit because of the rigid coupling provided by the control rod and piston assemblies. The actuator valve 14 supplies pressurized air to one air chamber while exhausting the other air chamber to drive one diaphragm outwardly toward an adjacent pump cavity and to pull the other diaphragm inwardly away from another adjacent pump cavity. In this way, there is an intake stroke in the right pump cavity and a pump stroke on the left pump cavity as the diaphragms move left. At the end of the stroke, the actuator valve reverses the flow and the pump functions are reversed as the diaphragms are forced to move to the right.

Looking specifically to the actuator valve 14, a unitary casting is employed in the preferred embodiment as housing 36. The housing 36 includes two parallel mounting plates 38 and 40 having flat outer surfaces for mating with the drive chamber housings 10 and 12. The cross-section of the actuator 14 inwardly of the mounting plates 38 and 40 is best seen in Figure 4. Strengthening webs 42, 44 and 46 extend between the mounting plates 38 and 40. In the upper portion of the casting are located the air inlet, the valve piston and the means for directing air into and out of the reciprocating device. Centrally located in the housing 36 is the control rod and bushing.

The valve piston 48 is positioned in a cylinder 50 formed within the housing 36. The valve piston 48 and cylinder 50 cooperate to provide two major functions. The first is to provide means for selectively directing incoming air to either air chamber 24 and 26 and exhausting the opposite chamber in an alternating manner. The valve piston 48 and cylinder 50 also cooperate to provide a means for directing incoming air to the ends of the valve piston 48 such that the piston is capable of shifting in response to the position of the reciprocating device. To accomplish these functions, the air inlet 52 is directed to the cylinder at a central position spaced from the ends of the cylinder as can best be seen in Figures 4 and 5.

In providing a means for charging and exhausting the air chambers of the reciprocating device, the valve piston 48 includes an annular groove or channel 54 which cooperates with an arcuate passage 56 cut in the side of the cylinder 50 to direct air to one or the other of two air chamber ducts 58 and 60 as best seen in Figure 3. With the channel 54 aligned with the air chamber duct 58, incoming air will pass through the air inlet 52, the arcuate passage 56, the channel 54 and into the air chamber duct 58. Each of the air chamber ducts 58 and 60 is aligned with a hole through the wall of the drive chamber housings 10 and 12. While air is entering one of the ducts 58 and 60, the other duct will operate as an exhaust passage. A cavity 62 exists in the center of the valve piston 48. This cavity enables the air flowing through the exhausting duct to flow through the cavity 62 and through ports 64 and 66 to one of two exhaust ducts 68 and 70. The exhaust ducts 68 and 70 extend to a ball check valve 72 as can best be seen in Figure 6. When the valve piston 48 is shifted from one end to the other of the cylinder 50, the flow through the air chamber ducts 58 and 60, the cavity 62 and the ports 64 and 66 is reversed. The shift in the valve piston 48 also causes one of the exhaust ducts 68 and 70 to become blocked off while the other is opened for exhausting the alternate one of the air chambers 24 and 26.

The second main function performed by the valve piston 48 and cylinder 50 is the control of the location of the valve piston 48. To this end, the valve piston 48 has a diameter which is slightly smaller than the diameter of the cylinder 50. Thus, air is able to flow in the clearance to both ends of the valve piston 48 regardless of its position in the cylinder 50. This clearance is not illustrated in the figures for simplicity. There are also two axial paths allowing a greater amount of air to selectively flow to one end of the other of the valve piston 48.

These axial paths each include a bore 74 and 76 and a hole 78 and 80 drilled into the respective bore. The holes 78 and 80 are spaced such that the distance from the inside edge to inside edge is the same as the width of the arcuate passage 56. Thus, only one of the holes 78 and 80 may be exposed directly to the incoming air in the arcuate passage 56 at one time. This selective direction of air through the holes 78 and 80 provides an effective anti-stall feature better described in the earlier patent No. 3,071,118.

To initiate the shifting of the valve piston 48, one or the other of two valve piston vent passages 82 and 84 is opened to atmosphere. These vent passages are located at the ends of the cylinder 50 as can be seen in Figure 5. During normal operation, the vent passage at the end furthest from the valve piston 48 is vented. The valve piston 48 then moves toward that vented end of the cylinder. During the stroke of the air driven reciprocating device associated with the actuator valve 14, neither end of the cylinder 50 is vented. It is only at each end of the working stroke that venting takes place.

During the working stroke of the air driven reciprocating device, air flows through the clearance between the valve piston 48 and the cylinder 50 and through one of the paths in the valve piston 48. Once pressure has built up at both ends, there is substantially no flow axially in the cylinder 50. Two bosses 86 and 88 form spacers on either end of the valve piston 48 such that an annular air space is created at the ends of the valve piston 48. This air space has been referred to as a shift chamber and acts as a potential energy storage mechanism to effect the shifting of the valve piston 48.

The cylinder and valve piston tolerance and air passage dimensions are such that the ends of the cylinder 50 may be vented much faster than they are replenished with incoming pressurized air. Thus, when venting occurs at one end of the valve piston chamber 50, a pressure imbalance is experienced by the valve piston 48. The shift chamber at the unvented end of the valve piston 48 has a reservoir of compressed air such that the venting of the other end releases the air spring to drive the valve piston 48 to the vented end of the cylinder. Once the valve piston 48 reaches just past half way in its shift through the cylinder 50, the shifting is aided by the axial path of the valve piston 48 extending to the unvented end of the cylinder 50. This mechanism insures a complete shift.

The incoming pressurized air also acts to force the valve piston 48 against the opposite side of the cylinder. This is accomplished even during low flow conditions because the ports 64 and 66 are vented. With these areas of lower pressure, a pressure imbalance is created such that the inlet air pressure will hold the piston against the opposite wall. This biasing of the piston is beneficial because the axial paths created by the valve piston clearance is more uniform and the valve piston can thus seal the air chamber ducts 58 and 60 and exhaust ducts 68 and 70 where appropriate.

The valve piston is contained within the cylinder 50 by means of the drive chamber housings 10 and 12 which define the ends of the valve piston chamber 50. Furthermore, a pin 90 extending into the bore 76 maintains the angular orientation of the valve piston 48.

To achieve the shifting of the valve piston 48 at the appropriate time, a control rod 15 is used. The control rod is fixed to reciprocate with the air driven reciprocating device by either a direct attachment or some conventional form of linkage. The control rod is positioned in a passageway through the housing 36. The control rod 15 further extends into the air chambers 24 and 26 to retain the diaphragm pistons at a fixed spaced distance from one another and in alignment. A bushing 94 fixed to the housing 36 and forming part of the housing provides a guide for the control rod 15.

The valve piston vent passages 82 and 84 extend from the ends of the cylinder 50 to circular grooves 96 and 98. The valve piston vent passages 82 and 84 cross over as can best be seen in Figure 8. Either the valve piston vent passages 82 and 84 or the air chamber ducts 58 and 60 should cross over to opposite ends of the actuator valve 14 so that air flow through the cavity 62 in the valve piston 48 will be toward the end which is abutting the end wall of the cylinder 50. On either side of each of the circular grooves 96 and 98 are circular seats which each contain an O-ring seal 100 through 106 to seal these circular grooves 96 and 98.

The control rod 15 includes an axial passage 110. The axial passage 110 includes truncated conical sections with a central cylindrical section having a reduced diameter from the main body of the control rod 15. This axial passage 110 is positioned between the circular grooves 96 and 98 such that when either of the inner O-rings 102 and 104 are encountered, air communication between the valve piston vent passages 82 and 84 and the axial passage 110 is achieved.

Between the inner O-rings 102 and 104, two control rod vent passages 112 and 114 extend to atmosphere. The control rod vent passages may be in any configuration between the inner seals 102 and 104. For example, one continuous passageway may be employed as flow only occurs when the axial passageway moves across one of the seals at 102 or 104. The outer seals at 100 and 106 are never disturbed by the axial passage 110. Thus, a constant seal is maintained to prevent any matter from entering into the bushing 94 from the air chambers 24 and 26.

Through the use of the single axial passage

110, there is no direct blow-by where pressurized air is lost through open seals. Thus, the air actually needed to fill the air chambers 24 and 26 to move the diaphragms 20 and 22 and the air needed to shift the valve piston 48 is substantially all that is used by the present device.

In overview, the operation of the actuator valve is in the nature of a feedback control system. That is, the location of the valve piston 48 determines the movement of the air driven reciprocating device. The movement of the air driven reciprocating device in turn controls the location of the control rod 15. The control rod location determines the position of the valve piston. The control of the stroke of the air driven reciprocating device is the width of the axial passage 110 and the distance between the seals at the O-rings 102 and 104. Roughly, the distance between the seals 102 and 104 minus the length of the axial passage 110 equals the stroke length of the reciprocating device.

Looking in greater detail to the pump itself, the drive chamber housings 10 and 12 are associated with pump chamber housings 28 and 30 to form opposed pump cavities. These cavities are most conveniently circular and are of sufficient depth to accommodate the full stroke of the pump. The diaphragms 20 and 22 divide each of the opposed pump cavities into air chambers 24 and 26 and pump chambers 29 and 31. The diaphragms 20 and 22 have a circular bead about the periphery of the diaphragm. Each bead 116 is positioned in two channels, one in the drive chamber housings 10 and 12 and one in the pump chamber housings 28 and 30. The bead acts to seal the chambers and to locate the housings relative to one another. The combination of the piston assemblies and the control rod 15 maintain the alignment of the diaphragm, contribute to uniform flexure and provide a feedback input to the actuator valve 14.

The pump chamber housings 28 and 30 define the outer walls of the opposed pump cavities forming pump chambers with the diaphragms 20 and 22. Each pump chamber housing 28 and 30 includes an inlet port 118 and an outlet port 120. The inlet port 118 is located at the lower end of the pump chamber housing and includes a ball check valve located therein. The ball check valve includes a ball 122, a seat 124 and ribs 126. The ribs 126 simply act to retain the ball 122 in the ball check valve. The seat 124 is conveniently positioned at the outer end of the inlet port 118 so that it can be easily replaced if necessary. The inlet port 118 terminates in a surface which is in a plane at roughly a 45° angle to the axis of the control rod 15. The outlet port 120 is simply a hole through the wall of the pump chamber housings 28 and 30 which terminates in a surface which is also at an angle relative to the control rod 15 of approximately 45°.

The inlet manifold 128 extends from a central inlet position 130 outwardly to the inlet ports 118 associated with each pump chamber housing 28 and 30. The inlet manifold 128 conveniently includes feet 132 in order that the pump will stand independently. An inlet passageway 134 extends from the inlet 130 to each of the inlet ports 118 such that a mating surface is provided adjacent each of the inlet ports 118 which will meet the surface extending at 45° relative to the control rod 15, the inlet manifold 128 being outwardly of the inlet ports 118. The valve seat 124 is positioned at the surface of each of the inlet ports 118 to hold the seat 124 in place by placement of the inlet manifold 128 as can best be seen in Figure 1.

An outlet manifold 126 is positioned above the main part of the pump and is diametrically opposed to the inlet manifold 128. The outlet manifold 136 also includes a central port and a passageway 140 extending to each of the pump chamber housings 28 and 30. The outlet manifold 136 includes outlet port ball check valves each including a ball 142, a seat 144 and placement ribs 146. The ball check valve is placed in the outlet manifold rather than in the pump chamber housings 28 and 30 such that the seat 144 may be at the joint between the pump chamber housings 28 and 30 and the outlet manifold 136 as can best be seen in Figure 1. The surface of each of the pump chamber housings 28 and 30 mating with the outlet manifold 136 is angled, as mentioned above, at 45°. The mating surfaces of the outlet manifold 136 are similarly angled such that the outlet manifold is outwardly of the pump chamber housings 28 and 30.

To tie the pump assembly together, tie rods 148 extend between the inlet manifold 128 and the outlet manifold 136. As can be seen in Figure 2, a pair of tie rods are positioned at one end of the pump. As can be seen in Figure 1, a second pair of tie rods 148 is positioned at the other end of the pump as well. In the present embodiment, the tie rods 148 include carriage bolts 150 threaded at one end to receive hand tightened nuts 152. These tie rods 148 act as means for forcibly drawing the inlet manifold 128 and the outlet manifold 136 together and provide a drawing line of force along the rods. The manifolds 128 and 136 have open ended slots 154 for receiving the tie rods 148 without completely separating the nut 152 from the bolt 150.

As can be seen in Figure 1, the mating surfaces between both manifolds and the pump chamber housings 28 and 30 are at acute angles relative to the direction of force imposed by the tie rods 148. As the tie rods are drawn together, the manifolds 128 and 136 are drawn together. This movement in turn forces the pump chamber housings 28 and 30 toward one another. Compression in the main body of the pump is then experienced to hold the diaphragms 20 and 22 between the drive chamber housings 10 and 12 and the pump chamber housings 28 and 30. The drive chamber housings 10 and

12 may also be retained in this compressed assembly against the actuator valve 14. In this way four tie rods 148 are capable of holding the entire pump assembly together. The angle of the mating surfaces to the tie rods is shown to be 45°. However, a 45° angle is not critical and may be increased or decreased depending on the amount of compression per unit of tension in the tie rods which may be desired.

Thus, an improved air driven diaphragm pump assembly is disclosed which is easy to assemble and which employs a minimum of parts. Consequently, diaphragms, check valves and the valve actuator may be changed very quickly with a minimum of down time and a minimum of potential assembly error. Also an improved actuator valve for an air driven reciprocating device is disclosed. While embodiments and applications of this invention have been shown and described, it would be apparent to those skilled in the art that many more modifications are possible without departing from the inventive concepts herein described. The invention, therefore, is not to be restricted except by the spirit of the appended claims.

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Claims

1. A pump having opposed pump cavities, a pump drive assembly (10, 12, 14) between said cavities forming an inner wall of each of said cavities, pump chamber housings (28, 30) meeting with said pump drive assembly to form the outer wall of each of said cavities, an inlet manifold (128) extending to and in communication with each of said cavities and an outlet manifold (136) extending to and in communication with each of said cavities, said inlet and outlet manifolds being diametrically opposed, wherein the improvement comprises

means (148) for forcibly drawing said manifolds toward one another;

said manifolds and said pump chamber housings including mating surfaces therebetween lying in planes at an acute angle to the line of force drawing said manifolds toward one another, said manifold mating surfaces each being outwardly of each associated pump chamber housing mating surface.

2. The pump of claim 1 wherein a diaphragm (20, 22) is positioned between said pump drive assembly and each said pump chamber housing to divide each said cavity into a drive chamber (24, 26) and a pump chamber (29, 31), each said diaphragm being oriented in a plane parallel to the line of force drawing said manifolds toward one another and being compressed by drawing said manifolds toward one another.

3. The pump of claim 1 wherein said communication between each of said cavities and each of said manifolds is controlled by ball check valves (122, 142).

4. The pump of claim 1 wherein said acute angle is approximately about 45°.

5. The pump of claim 1 wherein said means for forcibly drawing said manifolds toward one another include threaded fasteners.

6. An actuator valve for an air driven reci-

procating device, comprising a valve piston (48), a control rod (15) fixed to reciprocate with the air driven reciprocating device, and a housing (36) having a cylinder (50) closed at each end and enclosing said valve piston, a passageway through which said control rod extends, an air inlet (52) to said cylinder spaced from the ends of said cylinder, valve piston vent passages (82, 84) extending from the ends of said cylinder to said passageway, and control rod vent passages (112, 114) extending from said passageway to atmosphere, said valve piston cooperating with said housing to include means (78, 80) for directing incoming air to the ends of said valve piston and means (58, 60) for selectively directing incoming air to and exhausting outgoing air from the air driven reciprocating device, wherein the improvement comprises an axial passage (110) in said control rod positioned between said valve piston vent passages to vent selectively each of said valve piston vent passages to said control rod vent passages.

7. The actuator valve of claim 6 wherein the improvement further comprises said control rod vent passages being inwardly of said valve piston vent passages.

8. The actuator valve of claim 7 wherein the improvement further comprises seals (102, 104) outwardly of said control rod vent passages in said passageway.

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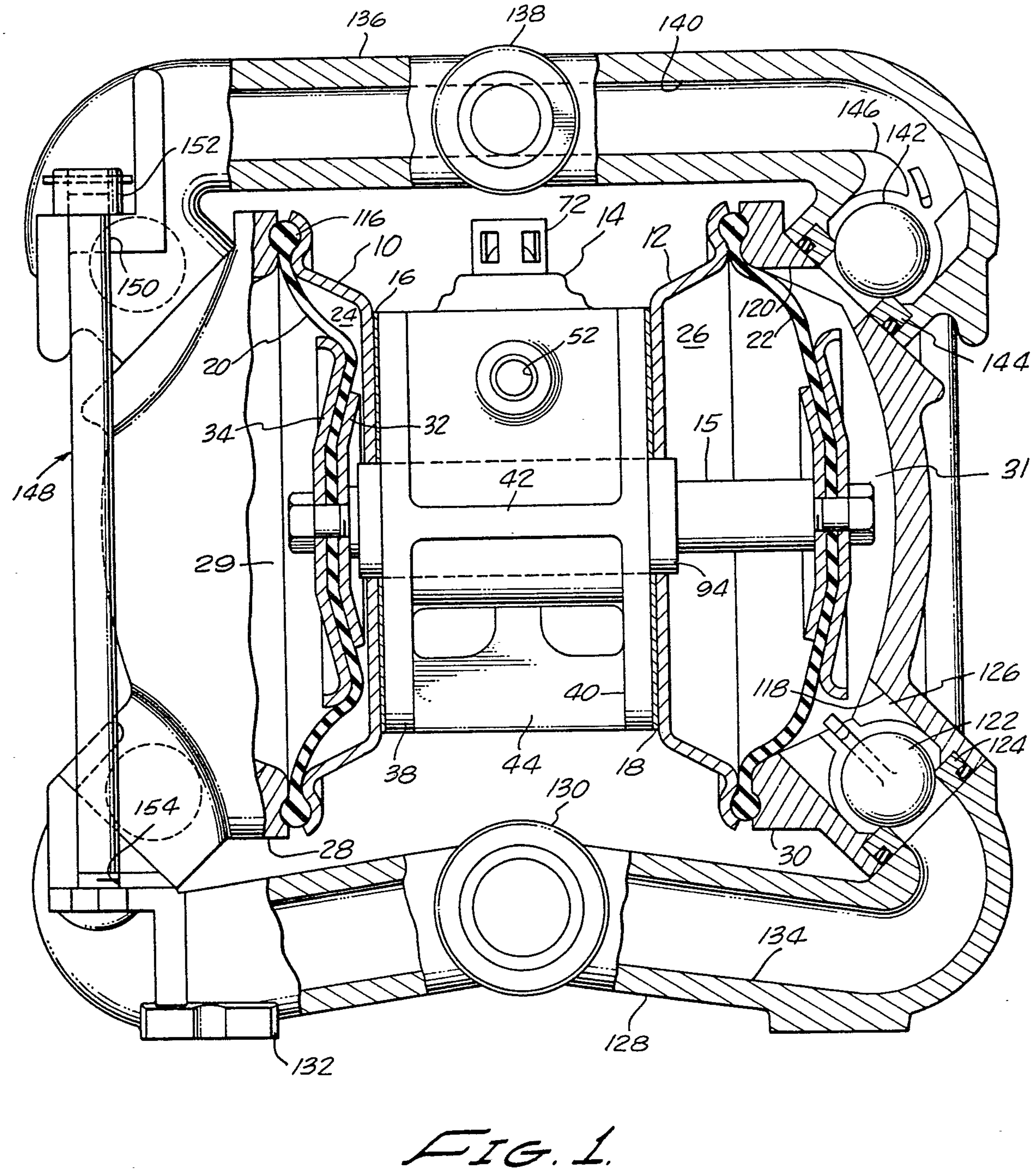

FIG. 1.

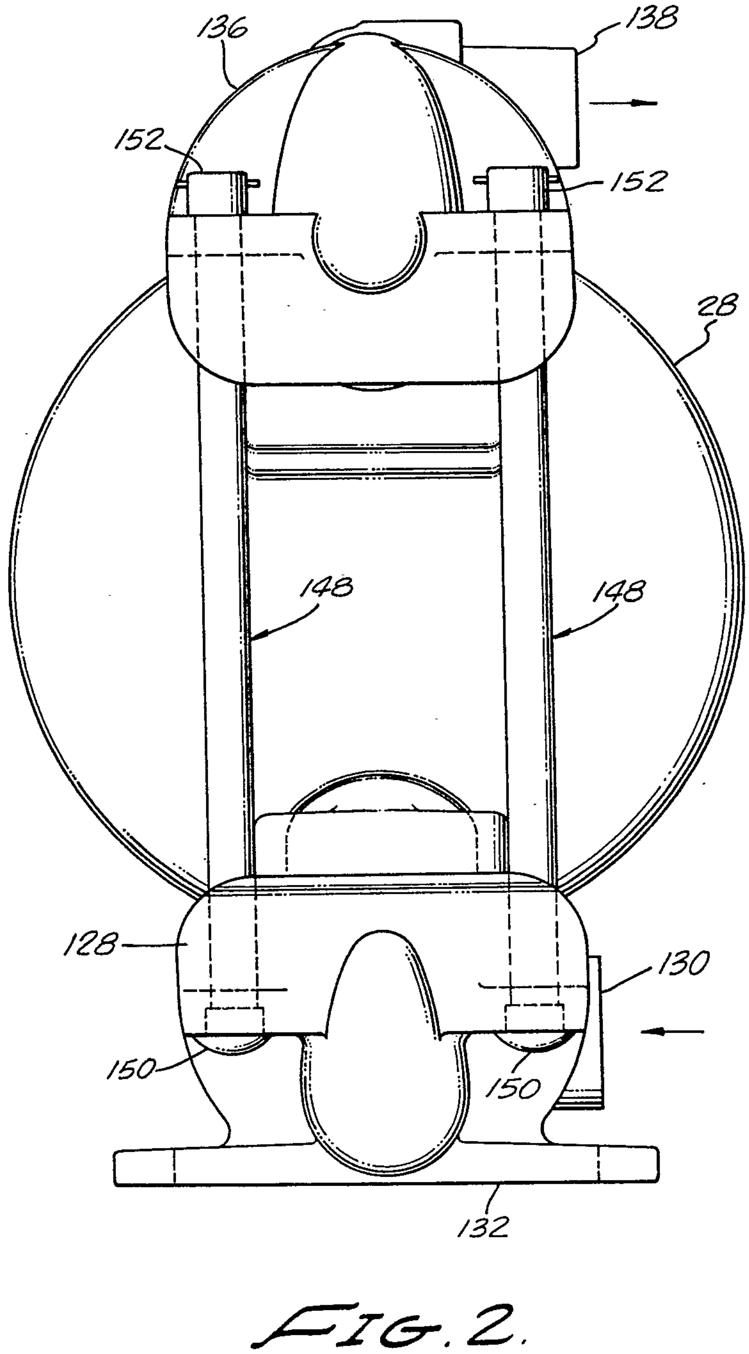

FIG. 2.

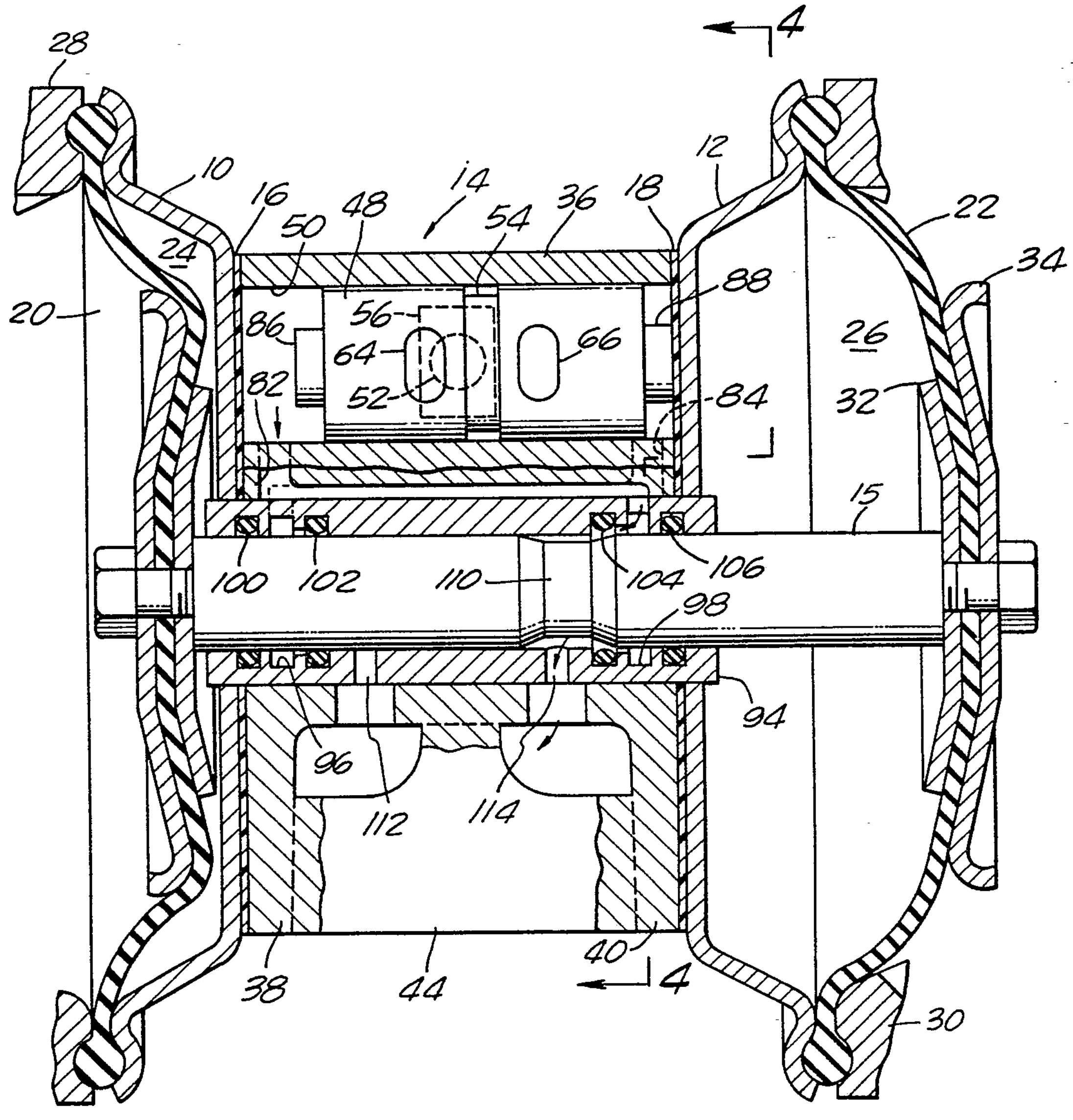

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FIG.3.

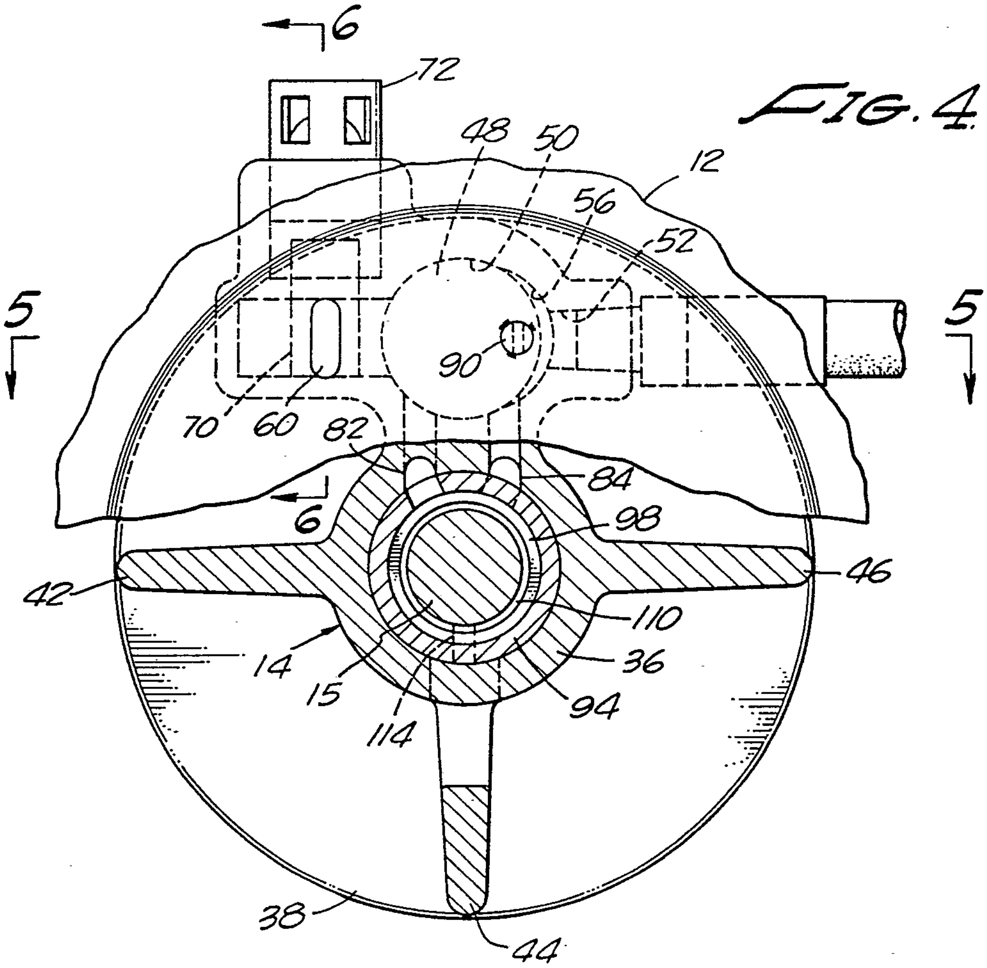
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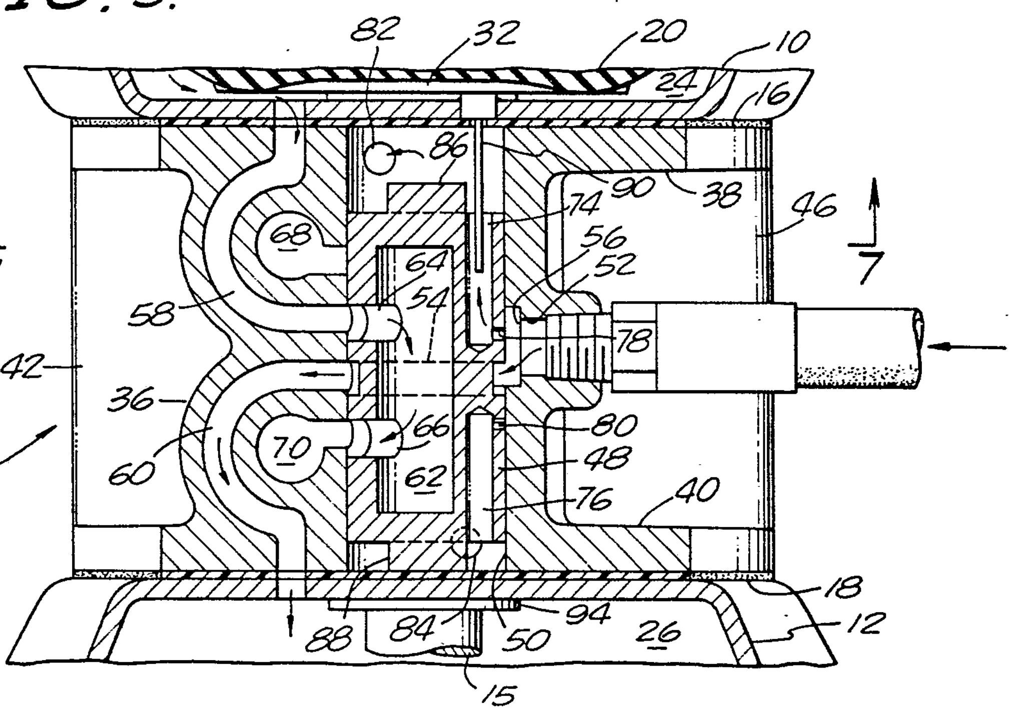
FIG. 4.

FIG. 5.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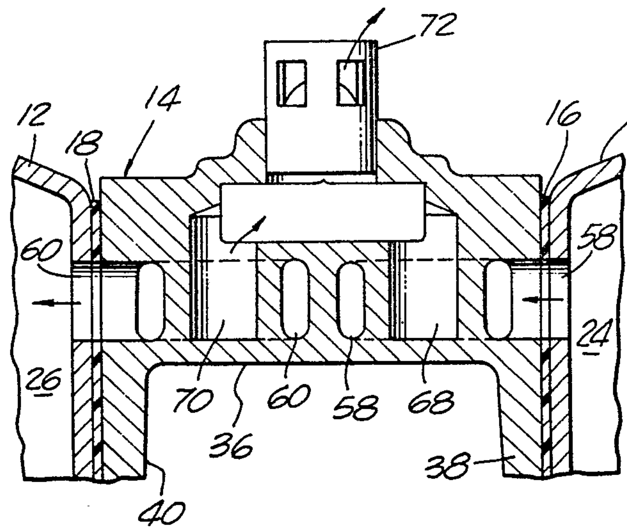

FIG. 6.

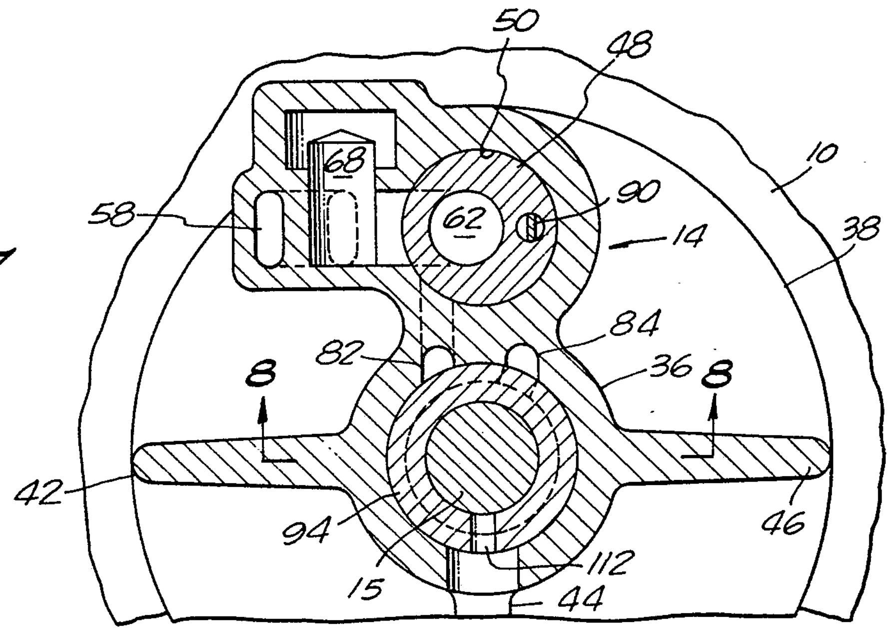

FIG. 7.

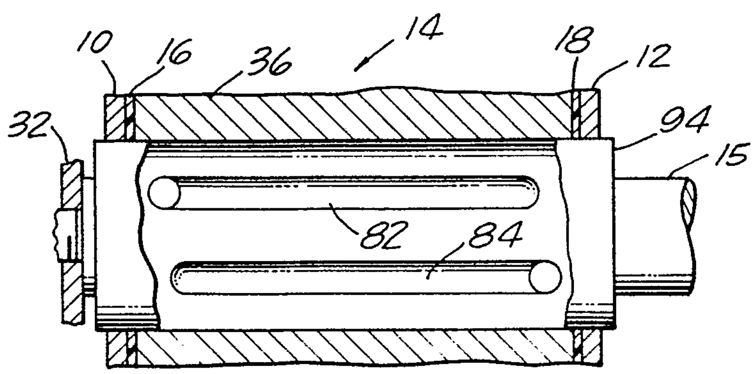

FIG. 8.

0018143

European Patent Office

EUROPEAN SEARCH REPORT

Application number
EP 80 30 1083

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
	US - A - 2 625 886 (BROWNE) * Column 2, lines 10-12, 33-53; column 4, lines 6-15, 71-75; column 5, lines 1-6; column 7, lines 52-65; column 8, lines 27-52; figures 1,4 * --	1-3,5, 6,8	F 04 B 43/06 F 01 L 25/06
	GB - A - 11.068 AD 1911 (BOONZAIER) * Page 5, lines 15,16, 37-41; figure 1 * --	1,3,4	
	US - A - 4 019 838 (FLUCK) * Column 2, lines 16-24; column 4, lines 51-53; figures 6,7 * --	6,8	TECHNICAL FIELDS SEARCHED (Int.Cl. 3) F 04 B
	GB - A - 1 379 594 (MORRISON) * Page 3, lines 9-29; figure 3 * ----	6,8	

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

X The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	30-06-1980	HEINLEIN