

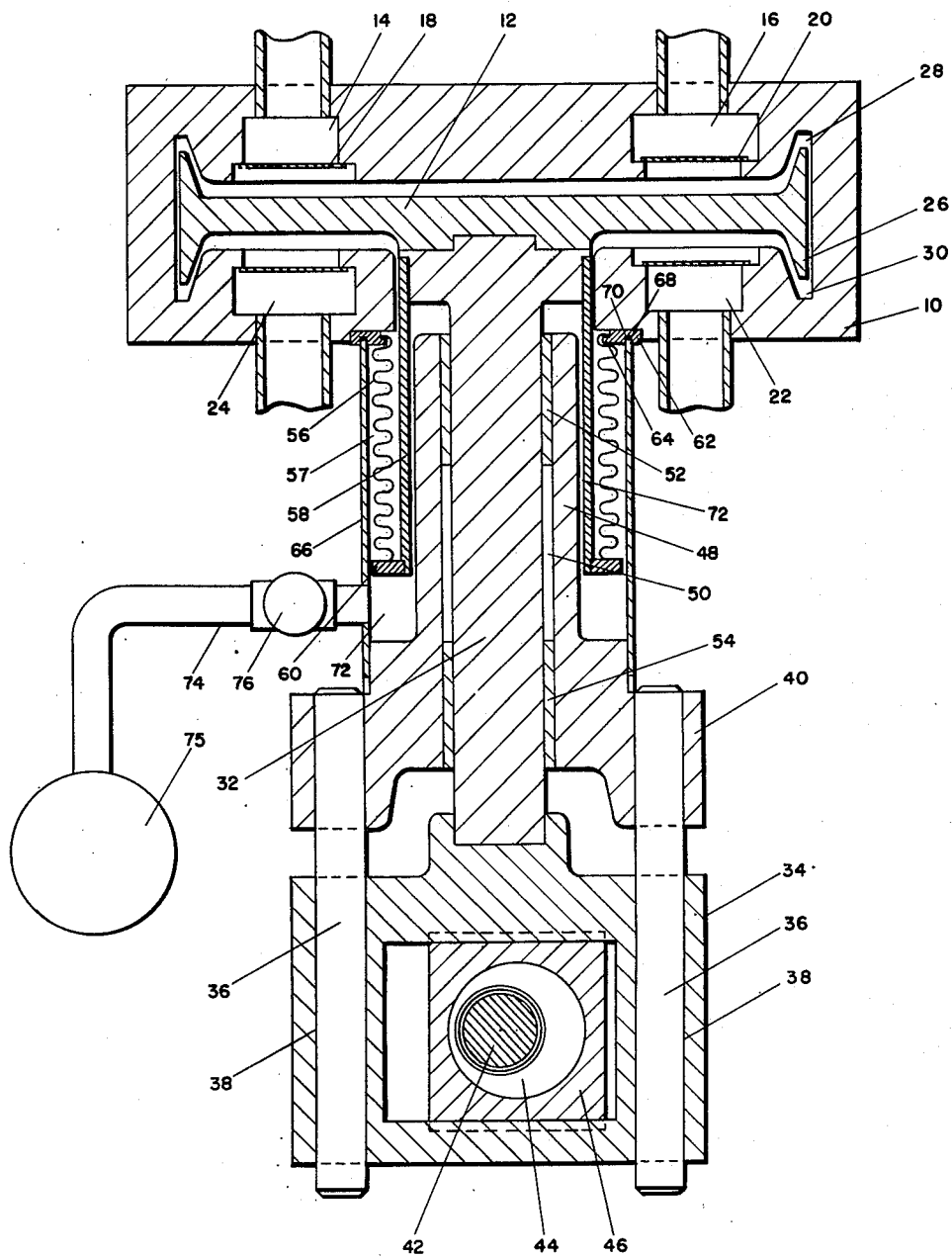
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SYLPHON SEALED PUMP

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SYLPHON SEALED PUMP

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This invention relates to reciprocating pumps and more particularly to an improved type of double acting reciprocating piston pump especially adapted for handling corrosive gases.

In handling highly corrosive gases such as, for example, fluorine or chlorine or their compounds, a number of special problems arise that are not ordinarily encountered in handling non-corrosive fluids. Such gases chemically attack all of the common lubricants and packing materials, thereby destroying their lubricating or sealing properties. Furthermore, the reaction products produced may contaminate the gas or gases being pumped. It is thus desirable that the corrosive gas and lubricant be prevented from coming into contact with one another. In the case of reciprocating pumps, one of the most effective methods of preventing such contact is to use a flexible metal seal, for example, a Sylphon bellows, between the moving parts of the pump and the stationary parts of the pump. Such a bellows may be sealed to the cylinder and to the piston or piston rod in such manner that the bellows expands and contracts as the piston moves with respect to the cylinder. The Sylphon-sealed pumps previously proposed have been subject to a number of disadvantages. When a Sylphon bellows is continually expanded and contracted there is a tendency for the bellows to fail because of fatigue. This tendency toward fatigue may be reduced by so constructing the pump that the movement of the bellows is relatively small and by making the average pressures inside and outside the bellows approximately equal. For example, the piston may be made in the form of a relatively thin plate and operated with a short stroke. However when a thin piston with a short stroke is used, leakage past the piston tends to become disproportionately large.

A further disadvantage of previous constructions has been that they have greatly increased the clearance volume between the cylinder and the piston at the end of its stroke, thereby decreasing the efficiency of the pump. Such an increase in the clearance volume is particularly disadvantageous in cases where a short stroke is used, since in such cases the ratio of the effective volume of the cylinder to the ineffective volume is relatively small.

It is accordingly an object of the present invention to provide an improved type of Sylphon-sealed reciprocating pump.

It is a further object of the invention to provide means for minimizing the tendency of

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the Sylphon seal of such a pump to fail due to fatigue.

It is still another object of the invention to minimize leakage past the piston of a reciprocating pump.

It is another object of the invention to provide a reciprocating pump capable of handling a highly corrosive gas efficiently and without contamination.

Other objects of the invention will be in part obvious and in part pointed out hereinafter.

The many objects and advantages of the present invention may best be appreciated by reference to the accompanying drawing which illustrates a preferred embodiment of the invention. Referring to the drawing, the numeral 10 designates a pump cylinder or casing in which the piston 12 is reciprocated. The piston 12 is of the flat plate type and is double acting. The cylinder 10 is provided with an upper inlet port 14 through which the gas to be pumped is drawn into the cylinder on the down stroke of piston 12 and an upper discharge port 16 through which the gas is forced on the up stroke of piston 12. The port 14 is provided with a leaf or flutter type valve 18 which prevents gas from passing through the port 14 on the up stroke of piston 12 and discharge port 16 is provided with similar valve 20 which prevents gas from being drawn into the cylinder through port 16 on the downstroke of piston 12. An inlet port 22 and discharge port 24 similar to the ports 14 and 16 are provided in the lower portion of the cylinder. Thus gas is pumped on both the up and downstrokes of the piston.

As indicated in the drawing, the piston has a relatively short stroke or travel and is made relatively thin and light. The lightness of the piston and shortness of stroke permit relatively rapid reciprocation of the piston. However as pointed out above, where such a thin piston is used in conjunction with a short stroke, leakage past the piston may become disproportionately large. In order to minimize such leakage, the piston 12 is provided with a peripheral flange 26 which extends upwardly and downwardly beyond the two faces of the piston. The cylinder 10 is provided with the peripheral recesses 28 and 30 which are shaped to conform with the peripheral flange of the piston. The recesses 28 and 30 permit relatively close clearances to be used between the piston and cylinder thereby increasing the efficiency of the pump. The peripheral flange 26 provides a relatively long leak-

age path, and therefore minimizes leakage of gas past the piston 12.

The piston 12 is connected by a piston rod 32 with a crosshead 34 that is guided in its vertical reciprocating motion by the guide rods 36. The guide rods 36 pass through holes 38 in the crosshead 34 and are fixed at their upper ends to the frame 40 of the pump. The crosshead 34 and piston 12 are given a reciprocating motion by rotation of a shaft 42 which may be driven by any suitable motive means (not shown). The mechanism interconnecting shaft 42 and crosshead 34 is commonly known as a "Scotch yoke." Fixed to the shaft 42 there is an eccentric 44 which fits into a circular hole in a sliding plate 46. At its top and bottom, the plate 46 is mounted in grooved tracks in the crosshead 34 in such manner that the plate can move in a horizontal direction. As the shaft 42 rotates, plate 46 is given a horizontal reciprocating motion and the crosshead 34 a vertical reciprocating motion. In this way the piston 12 may be given a rapid reciprocating motion in the cylinder 10.

The frame 40 is provided with an upwardly extending cylindrical collar 48 through which the piston rod 32 passes. The inner surface of collar 48 is spaced from the piston rod 32 to a sufficient extent to form an annular compartment 50 into which a suitable fluid lubricant may be pumped. The bearings 52 and 54 are provided between the piston rod and collar 48 to laterally guide and support the piston rod 32 and piston 12.

As pointed out above, it is desirable that the gas being pumped be kept out of contact with the lubricant and in order to achieve this objective, a metal seal, in this case the Sylphon bellows 56, is provided. The bellows 56 is located in a relatively narrow annular space 57 and is effectively connected to the cylinder and piston in such manner that the bellows expands and contracts as the piston is reciprocated. Fixed to the upper end of piston rod 32 there is a cylindrical sleeve 58 which is spaced from the piston rod and extends downwardly around the collar 48. At its lower end, sleeve 58 is provided with a ring or flange 60 to which the lower end of bellows 56 is sealed. The upper end of bellows 56 is secured to a ring 62 which is in turn affixed to the cylinder 10. At its upper and inner periphery the ring 62 is notched to form a projection 64 around which the upper end of bellows 56 may be wrapped to assist in forming a gastight joint between the bellows and ring.

It should be noted that even though the volume between bellows 56 and sleeve 58 is relatively large, its effect on clearance volume is overcome by the constriction between inner sleeve 58 and the lower portion of cylinder 10. This constriction limits the flow between the volume enclosed by the lower face of piston 12 and the lower portion of cylinder 10 and the volume enclosed by bellows 56 and inner sleeve 58 to the extent that the latter volume has negligible effect on pumping efficiency of the lower half of the cylinder.

Closely surrounding the bellows 56, there is an outer sleeve 66 that extends from the cylinder 10 to the frame 40. At its upper end, sleeve 66 fits into a notch 68 in ring 62, a gasket 70 being provided in the notch to form a tight fit between the sleeve and ring. Thus the sleeves 58 and 66 define the annular space 57 within which the bellows 56 expands and contracts.

During operation of the pump, there is some tendency for lubricant from the compartment

50 to work its way past the bearing 52 into the space 72 between sleeve 58 and collar 48 and between bellows 56 and sleeve 66. A pipe 74 having a valve 76 therein is provided for removing lubricant from the space 72. The pipe 74 may be connected to a suitable pump, such as a vacuum pump, diagrammatically indicated at 75, for removing lubricant from this space. It is evident that such lubricant cannot come in contact with the gas being pumped since the bellows 56 is hermetically sealed at each end.

As pointed out above, the life of the bellows 56 may be appreciably extended by operating with a minimum pressure difference across the bellows and the present construction provides for such operation. The sleeve 66 and collar 48 effectively form a sealed housing around the bellows 56. If, for example, the pump operates at below atmospheric pressure, the space 72 may be evacuated through pipe 74 to such an extent as to cause the average pressures inside and outside the bellows 56 to be substantially equal. If the pump operates at a pressure above atmospheric pressure a suitable gas, such as air, may be pumped into the space 72 to maintain the desired minimum pressure drop across the bellows. When using a short stroke and minimum pressure drop across the bellows it has been found that the bellows will operate for more than 30,000,000 strokes without mechanical failure.

From the above description, it is apparent that the present invention provides an unusually compact and efficient pump for handling a corrosive gas. The relatively short stroke of the pump increases the effective life of the bellows since the bellows is only compressed a relatively small amount during each stroke. The peripheral flange on the piston reduces leakage past the piston and the internal peripheral recesses in the cylinder permit close clearances to be used between the piston and cylinder. Since the clearance between the inner sleeve 58 and the lower portion of cylinder 10 is small, the space between inner sleeve 58 and bellows 56 does not seriously decrease the pumping efficiency of the lower half of the cylinder. The interior of the cylinder is completely sealed from oil-lubricated portions of the pump and therefore there is no possibility of the gas being pumped coming into contact with the lubricant.

Since many embodiments might be made of the above-described invention and since many changes might be made in the embodiment described, it is to be understood that the foregoing description is to be interpreted as illustrative only and not in a limiting sense.

We claim:

1. In a reciprocating pump, in combination, a cylinder, a piston within said cylinder, said piston being provided with a peripheral flange extending beyond at least one face thereof to reduce leakage between said piston and said cylinder and said cylinder having a peripheral recess formed in at least one end thereof, said recess being adapted to receive said flange, a small positive operating clearance being maintained between the periphery of said piston and the wall of said cylinder, a first sleeve member mounted on said piston, a second sleeve member mounted in fixed relation to said cylinder, flexible sealing means effectively interconnecting said first and second sleeve members and adapted to be flexed as said first sleeve member moves with respect to said second sleeve member, means for laterally

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guiding said piston and means for reciprocating said piston within said cylinder.

2. In a reciprocating pump, in combination, a cylinder, a piston within said cylinder, said piston being provided with a peripheral flange extending beyond the faces of said piston to reduce leakage between said cylinder and said piston and said cylinder having peripheral recesses formed in the ends thereof, said recesses being adapted to receive said piston flange, a small positive clearance being maintained between the periphery of said piston and the wall of said cylinder so that there is no mechanical contact between the periphery of the piston and the cylinder, a first sleeve member mounted on said piston and extending through an end wall of said cylinder, a second sleeve member mounted on said end wall externally of said cylinder and partially embracing said first sleeve member, a cylindrical metal bellows interposed between said two sleeve members, said bellows being sealed at one end to said first sleeve member and at its other end to said cylinder wall, means for laterally guiding said piston and means for reciprocating said piston within said cylinder and thereby flexing said metal bellows.

3. In a reciprocating pump, in combination, a cylinder, a piston within said cylinder, said piston being provided with a peripheral flange extending beyond at least one face thereof to reduce leakage between said piston and said cylinder and said cylinder having a peripheral recess formed in at least one end thereof, said recess being adapted to receive said flange, a small positive operating clearance being maintained between the periphery of said piston and the wall of said cylinder so that there is no mechanical contact between said piston periphery and said cylinder wall, a piston rod on said piston extending through a relatively narrow opening in an end of said cylinder fitting closely about said piston rod to form an annular flow restriction, a rigid bearing in which said piston rod is reciprocable for laterally guiding said piston, a sleeve on said piston rod embracing said piston rod and said bearing at least partially, a second sleeve mounted in fixed relation to said cylinder and embracing the first said sleeve, flexible sealing means effectively interconnecting said sleeves and adapted to be flexed as said sleeves move with respect to each other and means for reciprocating said piston within said cylinder.

4. In a reciprocating pump, in combination, a cylinder, a piston within said cylinder, said piston being provided with a peripheral flange extending beyond the faces of said piston to reduce leakage between said cylinder and said piston and said cylinder having peripheral recesses formed in the ends thereof, said recesses being adapted to receive said piston flange, the periphery of said piston being spaced by a small positive clearance from the inner wall of said cylinder so that there is no mechanical contact between said piston and said cylinder wall, a piston rod on said piston extending through a narrow opening in an end of said cylinder, a rigid bearing outside said cylinder in which said piston rod is reciprocable for laterally guiding said piston, a first sleeve on said piston extending through said opening and spaced from the wall thereof by a small, flow-restrictive clearance, said sleeve at least partially embracing said piston rod and said bearing, a second sleeve mounted on said cylinder end about said cylinder opening and partially embracing said first sleeve, a cylindrical

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metal bellows interposed between said sleeves, said bellows being sealed at one end to said first sleeve member and at its other end to said cylinder end, and means for reciprocating said piston within said cylinder and thereby flexing said metal bellows.

5. In a reciprocating pump, in combination, a cylinder, a piston within said cylinder, said piston being provided with a peripheral flange extending beyond one face thereof to reduce leakage between said cylinder and said piston, said cylinder having a peripheral recess formed in one end thereof and adapted to receive said flange, the periphery of said piston being spaced from the wall of said cylinder by a small positive operating clearance so that there is no mechanical contact between said piston periphery and the wall of said cylinder, means for laterally guiding said piston and means for reciprocating said piston within said cylinder.

6. In a reciprocating pump, in combination, a cylinder, a piston within said cylinder, said piston being provided with a peripheral flange extending beyond the faces of said piston to reduce leakage between said cylinder and piston, said cylinder having peripheral recesses formed at the ends thereof and adapted to receive said piston flange, the periphery of said piston being spaced from the wall of said cylinder by a small positive operating clearance so that there is no mechanical contact between said piston and said cylinder wall, means for laterally guiding said piston and means for reciprocating said piston within said cylinder.

7. In a reciprocating pump, in combination, a cylinder, a flat plate-like piston within said cylinder, a piston rod on said piston extending through a relatively narrow, flow-restrictive opening in an end of said cylinder, a rigid bearing in which said piston rod is reciprocable for laterally guiding said piston, a sleeve on said piston embracing said piston rod and said bearing, a housing embracing said sleeve, flexible sealing means effectively interconnecting said housing and said sleeve, means for adjusting the pressure within said housing outside said sealing means and means for reciprocating said piston rod, thereby to reciprocate said piston and to flex said sealing means.

8. In a reciprocating pump, in combination, a cylinder, a flat, plate-like piston reciprocable within said cylinder, a piston rod on said piston extending through a relatively narrow, flow-restrictive opening in an end of said cylinder, a rigid bearing in which said piston rod is reciprocable for laterally guiding said piston, a sleeve dependent from said piston and embracing said piston rod and said bearing, a housing embracing said sleeve, a flexible bellows effectively interconnecting said housing and said sleeve, means for adjusting the pressure within said housing outside said bellows and means for reciprocating said piston rod, thereby to reciprocate said piston and to flex said bellows.

9. In a reciprocating pump, in combination, a cylinder, a flat, plate-like piston reciprocable within said cylinder, a piston rod on said piston extending through a relatively narrow opening in a wall of said cylinder, a rigid bearing in which said piston rod is reciprocable for laterally guiding said piston, a sleeve on said piston extending through said opening and embracing said piston rod and said bearing, a small positive clearance being maintained between the wall of said opening and said sleeve to restrict the flow of fluid

therebetween, a cylindrical housing embracing said sleeve and sealed to the lower wall of said cylinder, a flexible bellows effectively interconnecting the lower wall of said cylinder and the lower end of said sleeve, means for adjusting the pressure within said housing and means for reciprocating said piston rod, whereby to reciprocate said piston and to flex said bellows.

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Number
611,455
1,239,869
1,489,912
1,527,545
1,546,397
1,670,799
1,757,997
1,923,519
1,931,833

5

10

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
500,720	Rebsamen	July 4, 1893

Number
115,422
475,326

15

Name	Date
May	Sept. 27, 1898
Block	Sept. 11, 1917
Winkler	Apr. 8, 1924
Emmerling	Feb. 24, 1925
Michelsen	July 21, 1925
Dornbirer	May 22, 1928
Greenwald	May 13, 1930
Tsserant	Aug. 22, 1933
Sparacino	Oct. 24, 1933

FOREIGN PATENTS

Country	Date
Germany	Nov. 15, 1900
Great Britain	Nov. 17, 1937