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LIQUID-OXYGEN PUMPS

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This invention relates to pumps, and, more specifically, to pumps for increasing the compression of liquid oxygen.

Reciprocating-piston liquid-oxygen pumps build up pressures of 3000 lbs. and higher, and it is of the greatest importance that tendencies for oxygen to escape be minimized or eliminated. The importance of this is increased because of the combustible nature of oxygen, and its tendency to flash when there is any significant pressure-drop. The difficulty in effectively compressing liquid oxygen and in minimizing leakage is, moreover, increased because ordinary lubrication is impossible in the presence of liquid oxygen. These difficulties are also increased because liquid-oxygen pumps are operated at temperatures below minus 200° F. and ordinarily at temperatures below minus 300° F.

The conditions of operation also increase the importance of simplicity and compactness of construction and of precise centering of all portions of the moving parts at all stages of the operation.

With the foregoing and other considerations in view, the present invention, in various of its aspects, contemplates the provision of sealing means which is tough and yet flexible at low temperatures, the provision of effective and positive self-sealing means operated by the liquid oxygen or other fluid being pumped, and the provision of a combined piston-rod-and-interior-piston arrangement having a non-canting driving action on a hollow exterior piston.

In accordance with the invention in one of its aspects, there is provided sealing means formed of a solidified plastic which does not become brittle at temperatures between minus 200° F. and minus 430° F. but which remains tough and flexible at such temperatures. Among such materials are polymerized fluorinated ethylenes (e. g., Teflon) and trifluorochloroethylene polymers (e. g., Kel-F).

In accordance with the invention in another of its aspects, there is provided a positive seal which is self-sealing in the sense that the liquid oxygen or other fluid seeking to escape is trapped in a chamber containing a sealing ring one annular portion of which has a surface in contact with one of the relatively-moving parts and an opposite surface exposed to the pressure of fluid within said chamber and another annular portion of which is tightly clamped against the other of the relatively-moving parts.

In accordance with the invention in still other of its aspects, a two-part piston is provided by extending the piston rod into the interior of a hollow piston, forward-driving surfaces are provided interiorly of the hollow piston at a point forward of the rear end of the hollow piston and preferably generally centrally thereof, and/or return-drive surfaces are provided at a forward point.

Further in accordance with the invention, various combinations of the features above indicated are provided.

The invention accordingly comprises the features of construction, combinations of elements, and arrangement

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of parts, which will be exemplified in the constructions hereinafter set forth and the scope of the application of which will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawings, in which:

Figure 1 is a transverse sectional view of the pump with the piston members in their forward position;

Fig. 2 is a similar view thereof with the piston members in their rearward position;

Fig. 3 is an enlarged view of the central portion of Fig. 2; and

Fig. 4 is an enlarged fragmentary sectional view showing a modification.

There is exemplified in Figs. 1-3 a form of oxygen pump embodying the invention. A hollow piston 10 is mounted for reciprocation within a cylinder 12, and is driven thru a lost-motion drive arrangement as herein-after described by a combined interior piston member and piston rod 14, which is hereinafter referred to merely as a "piston rod." During the rear stroke of the piston members, liquid oxygen, for example, at a pressure of one atmosphere, or other fluid is drawn into a pump-chamber 15 thru a passageway 16-17-18-19 from a liquid-oxygen chamber 20 and compressed, as to a pressure of 3000 lbs. When, during the forward stroke of the piston members, a desired pressure is built up, a valve 22 is forced open to a chamber 23 against the pressure of a spring 24, and the compressed liquid oxygen forced into the chamber 23.

At the beginning of the forward movement of the piston rod 14, an annular shoulder 26 thereon contacts an annular shoulder 28 on the inner surface of the hollow piston 10, closing the passageway 16-17-18-19 and driving the piston 10 forwardly with the piston rod 14 to force the liquid oxygen ahead of a shoulder 29 on the piston rod and ahead of the forward ends of the piston 10 and the piston rod 14.

At their forward ends, the piston rod and piston are formed with cooperating shoulders 30 and 31. It will be noted, as shown in Fig. 1, that these shoulders are separated when the shoulders 26 and 28 are in engagement during the forward movement of the piston rod and piston. When, however, the piston rod begins its rearward movement, the shoulder 26 moves away from the shoulder 28 until the shoulder 30 meets the shoulder 31, whereupon the piston 10 moves rearwardly with the piston rod 14 to the position of Fig. 2. As the shoulder 26 moves away from the shoulder 28, the passageway 16-17-18-19 is opened, permitting liquid oxygen from the chamber 20 to be drawn into the chamber 15.

Pursuant to the invention, the shoulder 28 is disposed well forward of the rear end of the piston 10, and preferably in a position generally centrally of its length, and the shoulders 30 and 31 are disposed near the forward ends of the piston members, so that tendencies for the piston to cant, with consequent binding, cocking, buckling, and/or uneven wearing, are minimized.

The piston rod is mounted within bushing 33 and stuffing box 34. The bushing 33 is carried in a wall portion 35 which serves as part of the closure for the chamber 20. Another portion of this closure is shown at 36. A bracket 36a serves to additionally support the cylinder. The stuffing box 34 is mounted on a wall portion 36c, which provides part of the closure for a chamber 36d, as does also the wall portion 35.

The piston rod 14 is reciprocated by a suitable drive mechanism, not shown, and is centered within the piston 10 by struts 37.

The cylinder 12 is provided with cold-resistant bush-

ings 38 and 39 which seal the space between it and the piston 10 as effectively as possible, and act as bearings for radial loading of the piston. In order, however, to provide a positive seal which will prevent, to a maximum extent, leakage of the liquid oxygen or other fluid, there is provided, in the interior wall of the cylinder 12, a chamber 40 which is open to the outer surface of the piston 10, and, within the chamber and lying against the outer surface of the piston 10 and tightly clamped against the rearward portion of the chamber 40, is an annular seal 42 which is formed of a cold-resistant plastic which is of the nature indicated above and may be one of the types indicated above.

In the present instance the cylinder is cut away as indicated at 44 and the chamber 40 is provided within metal annuli 45, 46, and 47. The space forward of the annulus 45 and the space between the annulus 45 and the annulus 46 are both closed by cold-resistant sealing material 48. The rear end of the sealing annulus 42 is clamped firmly between the annuli 46 and 47, the latter of which has a forward extension 49 at its inward edge over which the sealing annulus 42 is curved. In the present instance the forward portion of the sealing annulus 42 is urged against the outer surface of the piston 10 not only by the pressure of the liquid oxygen or other fluid which leaks into the chamber 40 between the forward portions of the cylinder and piston and past the bushing 38 and the annulus 45, but also by a metal ring 50; but in many instances this ring may be omitted as indicated in Fig. 4, the pressure of the liquid oxygen within the chamber 40 being in itself sufficient to press the forward end of the sealing ring 42 against the outer surface of the piston 10 with such firmness as to prevent substantial leakage of oxygen past the point of contact of the sealing ring 42 with the piston.

The space between the self-sealing annulus 42 and the wall 36 is vented as at 52 to leak into a chamber 53 any oxygen or other fluid which may by-pass the self-sealing annulus 42.

Since certain changes may be made in the above construction and different embodiments of the invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

The invention claimed is:

1. A pump comprising a piston cylinder, a hollow piston reciprocable therein, a piston rod reciprocable within said piston, a rearwardly-facing shoulder on the inner surface of said piston at a point forwardly of the rear portion thereof, a shoulder on said piston rod adapted to engage the first-mentioned shoulder, said piston being recessed rearwardly of the first-mentioned shoulder to permit rearward movement of the piston rod therewithin, a forward shoulder at a forward portion of said piston, a rearward shoulder at a forward portion of said piston rod adapted to engage said forward shoulder after rearward movement of said piston rod within said piston, a fluid passageway having a rearward portion between said piston and said piston rod and a forward portion extending forwardly of the forward ends of said piston and said piston rod, said rearward portion being adapted to be closed by engagement of the second-mentioned shoulder with the first-mentioned shoulder, and rearwardly-spring-pressed valve means in said forward portion for closing said forward portion except when opened by the forward movement of fluid within said forward portion upon forward movement of said piston and piston rod after engagement of said shoulders.

2. A pump as set forth in claim 1 wherein an interior surface of a portion of said piston cylinder surrounding said piston is formed with an annular chamber open to the outer surface of said piston and wherein there is provided therein an annulus tightly secured to one side of said chamber and adapted to lie against said surface

and to be pressed thereagainst by the pressure of fluid leaking into the other side of said chamber.

3. A liquid oxygen pump or the like comprising a piston cylinder, a hollow piston movable within said cylinder, a piston rod movable forwardly within said piston for a given distance and thereupon engaging the piston to move the same forwardly for a further distance, an outlet passageway extending forwardly from said piston and said piston rod, rearwardly-seating and rearwardly-spring-pressed valve means in said passageway, a second passageway between said piston and said piston rod and communicating with the aforesaid passageway, cooperating portions on said piston and piston rod to close said second passageway when said piston rod engages said piston prior to moving said piston forwardly to force fluid forwardly to open said valve means, said cylinder being formed with an annular chamber open to the surface of said piston, and an annular seal in said chamber and formed essentially of a halo-ethylene polymer and having an annular portion secured to a transverse side of said chamber and an annular portion lying against the surface of said piston and to be pressed thereagainst by fluid escaping along the adjoining surfaces of said piston and cylinder.

4. A pump comprising a hollow reciprocable piston having an entrance portion and an exterior cylindrical surface, a piston cylinder having an exit portion and an interior cylindrical surface, said exterior cylindrical surface being in sliding engagement with said interior cylindrical surface, means for controlling the flow of fluid from said entrance portion to said exit portion in response to the operation of said piston, an annular recess in one of said cylindrical surfaces open to the other of said cylindrical surfaces, and a sealing annulus having an annular portion with a surface lying against the other of said surfaces and with an opposite surface exposed to fluid within said recess so as to be pressed against said other of said surfaces by fluid tending to escape from said exit portion between said cylindrical surfaces into said recess, means including another annular portion of said annulus and forming a fluid-tight seal between the wall of said recess and the aforesaid annular portion of said annulus, said sealing annulus being composed of a plastic which is tough, flexible, and non-brittle at temperatures below minus 200° F.

5. A pump comprising a piston cylinder, a hollow piston having a rearward portion and having a forward portion with an imperforate continuous wall and reciprocable within said cylinder, a piston rod reciprocable within said hollow piston and having a forward end portion with a wall spaced from the aforesaid wall to provide a channel for the free flow of liquid within the forward portion of said hollow piston and having a rear end portion providing a channel for the free flow of liquid within the rearward portion of said hollow piston and having a forwardly-facing driving portion between said forward end portion and said rear end portion, a rearwardly-facing seat on said hollow piston between said channels and adapted to be engaged by said driving portion during the forward stroke of said piston rod to close communication between said channels and to drive said hollow piston forwardly, said driving portion being withdrawn from said rearwardly-facing seat at the beginning of the rearward stroke of said piston to open communication between said channels, rearwardly-facing shoulder means on said piston rod, a forwardly-facing seat on said hollow piston adapted to be engaged by said shoulder means during the rearward stroke of said piston member to draw said hollow piston rearwardly without closing communication between said channels, means extending from a forward portion of said cylinder and providing an outlet conduit, and valve means disposed in said outlet conduit and adapted to be open when said hollow piston is driven forwardly and to close when said hollow piston is drawn rearwardly.

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6. A pump as set forth in claim 5 wherein there is provided means to impart to said piston rod reciprocating movement such that a major portion of said hollow piston is always within said cylinder.

7. A pump as set forth in claim 5 wherein there is provided fluid-containing chamber means surrounding the greater part of said cylinder, a portion of said chamber means communicating with the second-mentioned channel.

8. A pump as set forth in claim 5 wherein said valve means is in the form of a spring-pressed element blocking flow from the forward end of the cylinder but opening in response to the pressure of liquid within said hollow

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piston when said piston rod and said hollow piston are moved forwardly.

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