

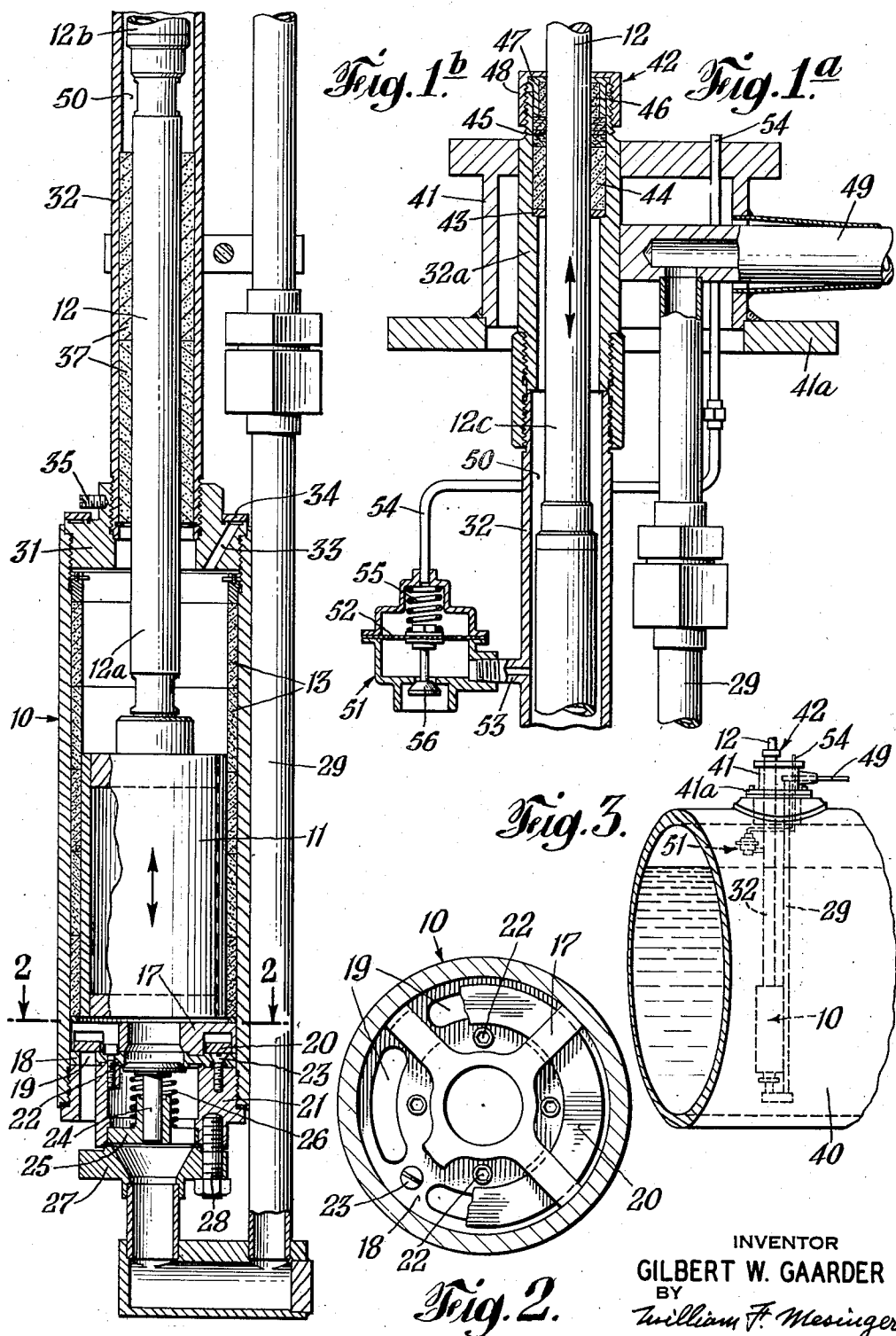
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IMMERSION PUMP FOR LIQUEFIED GASES

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IMMERSION PUMP FOR LIQUEFIED GASES

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6 Claims. (Cl. 103—153)

The invention is concerned with a reciprocative pump adapted for the pumping of highly volatile liquefied gases such as liquid oxygen. The pump is particularly adapted to be employed as an immersion type in which the working barrel at least is submerged in the liquid in the immediate supply tank with the piston rod and operating connections extending outwardly and exteriorly of the tank. The inner working end may therefore be termed the cold end and the outer end which includes the piston packing means is the warm end.

The pump is capable of relatively high capacity at moderate pressures in the range normally below 500 lbs. per square inch such as in pumping liquid oxygen in industrial installations where the oxygen is delivered to a converter for vaporizing it to a gas to be supplied to consumption apparatus. Liquids of such character have a very low boiling point and the pumping thereof involves problems of vaporizing of the liquid within the pump and consequent gas binding. On the other hand low temperatures at the packing means must be avoided in order to avoid excessive friction and wear and to accomplish the necessary maintenance of a tight seal. The present pump is designed to cope successfully with these factors in a relatively simple and economical manner and serve to deliver liquid at a relatively high rate in proportion to the size of the pump.

Features of particular importance involve an association or combination of elements designed to insure against cold liquid or gases which may leak past the piston progressing through the piston rod guiding means and coming into contact with the piston rod packing, and also to insure against relatively warm air leaking in the reverse direction inwardly from the packing with consequent transfer of heat to the working cylinder and liquid and possible contamination of the liquid.

The invention also embodies various structural features including certain valve arrangements contributing to the practicability of the pump as a whole.

The invention accordingly comprises the features of construction, combination of elements, and arrangement of parts, which will be exemplified in the construction hereinafter set forth, and the scope of the invention will be indicated in the claims.

Reference should be had to the following detailed description taken in connection with the accompanying drawings in which:

Figs. 1a and 1b comprise a vertical section of an immersion pump embodying the principles of the present invention, Fig. 1a showing the upper end thereof and Fig. 1b the lower end;

Fig. 2 is a horizontal section on the line 2—2 of Fig. 1b; and,

Fig. 3 shows a typical installation of the pump in a large supply tank, a section only of the tank being pictured.

The cold end of the pump embodying the working chamber is shown particularly in Fig. 1b, the parts comprising a cylinder 10 having therein pumping elements

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comprising a single acting piston 11 reciprocative through a long piston rod 12 by any suitable power means connected at the upper end of the rod extending from the top in Fig. 1a.

The cylinder is lined with a shell of self-lubricating material which conveniently may be made in successive cylindrical sections 13. The material may advantageously be a bonded carbon and particularly bonded graphite. Alternatively, the cylinder wall could be of smooth metal and the piston 11 lined with rings of the solid self-lubricating material or the piston may have spaced rings of solid self-lubricating material. An alternative self-lubricating material may be molybdenum disulfide bonded with a fluorinated hydrocarbon such as "Fluorothene." For example, the material may be 10 to 95% of molybdenum sulfide and the balance polytetrafluoroethylene or polychlorotrifluoroethylene.

The closure for the bottom end of the cylinder includes a compact symmetrical arrangement of both intake and outlet valve means each of relatively large total flow area. The elements include an inner spider 17, and an annular valve plate 18 having a series of arc-shaped ports 19 therethrough. An inlet check valve in the form of a flat ring 20 is adapted to seat by gravity over the ports 19. An outer closure member 21 is provided having a cylindrical portion screw threaded into the bottom end of the cylinder and an outer flange compressed against the end of the cylinder. The valve plate 18 is secured to the outer closure member 21 by an inner series of socket screws 22 and an outer series of set screws 23, the latter being counter-sunk below the upper surface of the valve plate 18. A central opening extends through the spider 17, valve plate 18 and closure member 21 comprising the liquid outlet which is controlled by a poppet valve 24 having a stem slidably mounted in a central boss of a spider 25 fitted within a counterbore in an outer sleeve portion of the closure member 21. The valve is urged to its seat by a compression coil spring 26 encircling the central boss of the spider 25. A coupling 27 for the outlet conduit is secured to the end closure 21 by bolts 28. The discharge pipe 29 connected to the coupling 27 extends upwardly alongside the pump.

The pump is single acting and the upper end of the cylinder has a closure plate 31 screw threaded into the upper end of the barrel 10. A piston rod sleeve 32 is in turn screw threaded into a boss in the cylinder closure cap 31. The cylinder is provided with a vent means for the upper end of the working cylinder comprising, as shown, one or more ports 33 extending through the end plate 31 and controlled by a flat annular valve 34 normally held by gravity in closure position over the ports 33 to prevent intake of gas or liquid upon the down stroke of the piston but adapted to permit escape of gases upon upward movement of the piston. The pump is adapted to be submerged in the liquid being pumped and normally the liquid would extend up over the valve 34. Set screws 35 limit the upward movement of valve 34, there being preferably 3 screws 35.

Guide means for the piston rod 12 are provided within the sleeve 32 comprising one or more guide bushings 37 which may be of material similar to the liner sleeves 13 of the working chamber. The piston 11 has a relatively close working fit in the cylinder liner sleeves and similarly the guide bushings 37 are designed to provide a sliding fit for the rod 12, the clearance in each case being preferably not more than about .003 or .004 of an inch. The relatively free sliding fit in the carbon sleeves results in low friction and heat generation, but of course despite the length of the piston 11 some fluid may leak past it. With the incorporation, however, of the vent 33 very little or no cold gases will escape upwardly through the bushings 37.

In a normal installation the pump is located in a supply tank such as that shown at 40 in Fig. 3 with the pump working chamber located near the bottom thereof below the liquid level. In such case the piston rod 12 and its sleeve 32 will have considerable length, for example a length of several feet, and normally much greater than the length of the stroke. The length of the working chamber is equal to the sum of the length of the piston, the stroke, and the clearance space between the end of the working chamber and piston at the ends of the stroke.

Fig. 1a shows the upper end of the sleeve 32 and piston rod 12 including an auxiliary coupling sleeve portion 32a and an end supporting bracket 41 provided with packing means 42 for the upper end of the piston rod. The packing is of a type including self-lubricating inert materials such as is disclosed in the patent to Patterson No. 2,292,543. As specifically shown in the present case, it includes an inner metal plate 43, a sleeve 44 of bonded self-lubricating material similar to that of the liner 13, packing rings 45 which may be composed of graphite impregnated woven asbestos and an outer sleeve 46 of solid self-lubricating material. The packing is compressed by an outer gland 47 pressed inwardly by the nut 48 threaded on external threads on the end of the sleeve portion 32a. As shown, the discharge pipe 29 connects into the bracket 41 and, through suitable coupling means, leads out through pipe 49 to the apparatus to which it is desired to deliver the liquid. The bracket 41 is welded at its lower end to a flange 41a adapted to be secured gas-tightly on a correspondingly flanged opening in the top of the supply container 40. It will be noted that the bracket 41 including the piston rod packing means are located exteriorly of the supply container and are adapted to be maintained at a warmer temperature and that the pump assembly is removable from the container 40 for easy servicing.

As an aid in maintaining the temperature differential between the exposed outer warm end and the cold inner working chamber, the lower sections of the piston rod 12 are preferably made hollow, and likewise the piston 11 may be hollow. The reduced weight resulting from the hollow construction has the further advantage of reduced inertia in the reciprocatory motion. The piston rod is shown as comprised of a plurality of sections suitably joined together. The lower sections 12a and 12b may be hollow, as described, and the uppermost section 12c to which the operating means is connected may be made solid as shown, but of reduced diameter through the packing means 42. Rod section 12c could also be tubular if desired. Preferably the piston and at least the lower sections of the piston rod are also made of a material which has a low heat conductivity such as stainless steel.

The lower end section 12a has a close sliding fit in the guide bushings 37 as has been described, and the uppermost section 12c has, of course, a fluid tight fitting in the packing. The intermediate area, however, is preferably of lesser diameter than the surrounding sleeve parts leaving an open annular space which may comprise a substantially isolated dead gas space 50. Because of the possible pumping action, however, of the upper end of the piston and exhausting action of the valve 34, or other conditions, such as rapid cooling of the vapor, a fluid pressure balancing means may be provided to prevent ingress of atmospheric air through the packing means into the open space 50 within the sleeve 32. Such means comprises a pressure responsive device 51 which includes an outer shell with a fluid tight diaphragm 52 therein, the space below the diaphragm communicating with the space 50 within the sleeve 32 through a coupling 53. The space above the diaphragm 52 is connected through a tube 54 with the atmosphere. In addition, a light compression spring 55 may be inserted adapted to act on the upper side of the diaphragm 52. In the normal operation a slight pressure above atmospheric may exist in

the space 50 due to the presence of vapor which has leaked thereinto from the pump and become warm and the valve 56 connected to diaphragm 52 will remain closed. If through cooling or other effects the pressure within the space 50 below the packing 42 should become less than atmospheric, there would be a tendency for air to leak past the packing into the space. This is prevented, however by the arrangement which is so adjusted and designed that upon the pressure in the space 50 dropping below atmospheric the reduced pressure on the lower surface of diaphragm 52 will cause the valve 56 to be opened exposing the area within the sleeve 50 to the pressure within the gas space in the upper area of the supply tank 40 which, in any event, will be not less than atmospheric and accordingly maintaining the pressure in the space 50 within the sleeve at at least atmospheric.

Instead of the valve 51 an open vent at 53 to the gas space of the container 40 may be employed. With a vent open to chamber 40, a suction created by the pumping action in the upper part of cylinder 10 would tend to draw gas from space 50 through the sliding clearance between rod portion 12a and bushings 37, but evacuation of space 50 will be prevented by the open vent which maintains the pressure acting under packing 44 to a value about equal to the pressure of tank 40. When valve 51 is used, the pumping action can usefully reduce the pressure under the packing to a value only slightly above atmospheric so that packing pressure and friction can be kept very small. The valve further avoids the danger of reducing the pressure under the packing to a value below atmospheric which might cause air leakage into space 50.

With the arrangement described, including the vent valve 34, it will be seen that a substantially stagnant body of gas is maintained within the open space 50 of the sleeve 32, and the warm packing end of the pump and the cold working chamber are to a large extent thermally isolated from each other.

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 drawing shall be interpreted as illustrative and not in a limiting sense.

I claim:

1. In a reciprocative piston pump for pumping highly volatile liquefied gas the combination of, a pump cylinder and a piston therein, a piston rod extending outwardly therefrom, said cylinder having a sleeve extension for said rod with a rod guide bushing therein and packing means disposed outwardly from said guide bushing, and means for preventing ingress of air through said packing means comprising a fluid conduit opening into the interior of said sleeve between said guide bushing and said packing means communicating with a source of the material being pumped, a control valve interposed in said conduit, and having means responsive to changes in the fluid pressure within said sleeve for opening and closing said valve.

2. In a reciprocative piston pump for pumping highly volatile liquefied gas the combination of, a pump cylinder and a piston therein, a piston rod extending outwardly therefrom, said cylinder having a sleeve extension for said rod with rod guide bushing means therein and outer packing means disposed in outwardly spaced relation to said guide bushing means, and means for preventing ingress of air through said packing means comprising a fluid conduit connecting the interior of said sleeve between said guide bushing means and said packing means with a source of the material being pumped, a control valve in said conduit having means responsive to changes in the fluid pressure within said sleeve for opening said valve when the pressure therein falls substantially below atmospheric, and closing said valve when the pressure therein rises substantially above atmospheric.

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3. In a reciprocative piston immersion pump for pumping highly volatile liquefied gas having an inner cold end and an outer warm end the combination of, a pump cylinder at said cold end adapted to be mounted within a supply tank of such material, a piston in said cylinder, a piston rod extending outwardly therefrom, said cylinder having a sleeve extension with a guide bushing of bonded carbon therein for said rod, outer rod packing means at said warm end, and means for preventing ingress of air through said packing means comprising a fluid conduit opening into the interior of said sleeve between said guide bushing and said packing means communicating with a source of the material being pumped, a control valve for said conduit, including means responsive to the fluid pressure within said sleeve for opening and closing said valve when the pressure therein falls below and rises above, respectively, a predetermined value.

4. In a reciprocative piston pump for pumping highly volatile liquefied gas the combination of, a pump cylinder and a piston therein, a piston rod extending outwardly from one side of said piston, said cylinder having a sleeve extension for said rod with rod guide bushing means therein and outer packing means spaced from said guide bushing means, fluid intake and outlet means connected to said cylinder at the end opposite to said sleeve, means for preventing ingress of air through said packing means comprising a fluid conduit opening into the interior of said sleeve between said guide bushing means and said packing means communicating with a source of the material being pumped, a control valve for said conduit including means responsive to the fluid pressure within said sleeve for opening and closing said valve when the pressure therein falls below and rises above, respectively, a predetermined value, and fluid vent means for the cylinder at said sleeve end adapted upon reciprocation of the piston to permit escape of liquefied gas which has leaked past said piston but preventing ingress of liquefied gas through said vent means.

5. In a reciprocative piston pump for pumping highly volatile liquefied gas the combination of, a pump cylinder

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and a piston therein, a piston rod extending outwardly from one side of said piston, said cylinder having a sleeve extension for said rod with rod guide bushing means therein and outer packing means spaced from said guide bushing means, fluid intake and outlet means connected to said cylinder at the end opposite to said sleeve, a fluid conduit opening into the interior of said sleeve between said guide bushing means and said packing means communicating with a source of the material being pumped for preventing leakage of air through said packing means, and fluid vent means for the cylinder at said sleeve end adapted upon reciprocation of the piston to permit escape of liquefied gas which has leaked past said piston but preventing ingress of liquefied gas through said vent means.

6. In a liquid supply chamber for holding a supply of high volatile liquefied gas, an immersion pump mounted in said supply chamber having a working chamber submerged in said highly volatile liquefied gas, a piston in said working chamber, a piston rod extending outwardly from said piston, a rod enclosure extending outwardly from said working chamber to a warmer region, means in said enclosure providing for said piston rod a submerged fluid-sealed inner cold end adjacent the rod end of said piston, an exposed fluid-sealed outer warm end and an annular space intermediate said warm and cold ends, vent means connecting into said supply chamber for maintaining a substantially stagnant body of gas in said space and annular means for venting said working chamber at the rod end of said piston for discharging gas material into said supply chamber.

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