

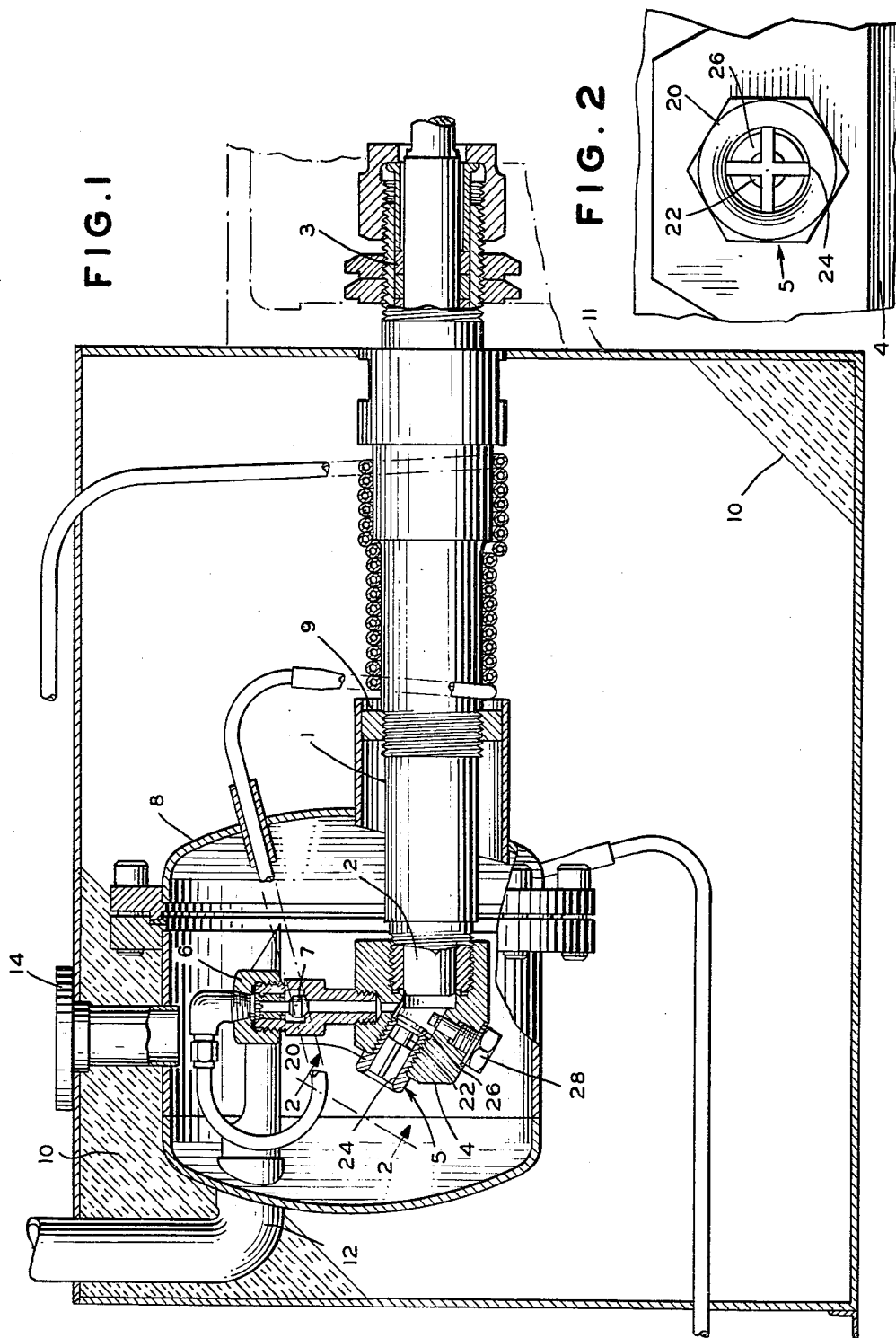
April 2, 1963

L. E. PUTMAN
LIQUEFIED GAS PUMP

3,083,648

Filed Feb. 25, 1959

2 Sheets-Sheet 1



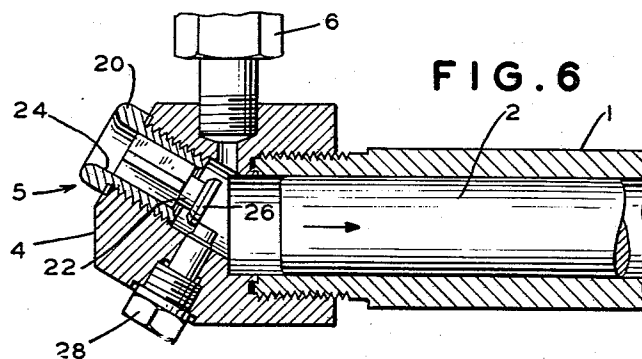
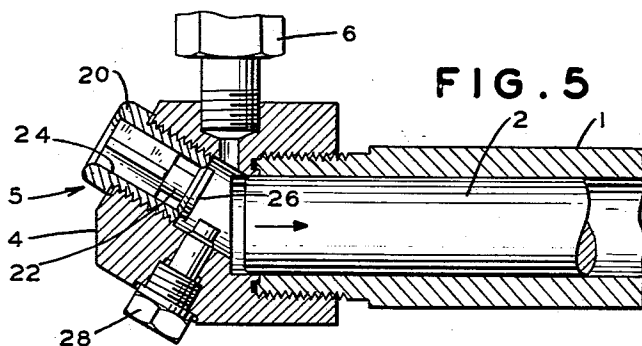
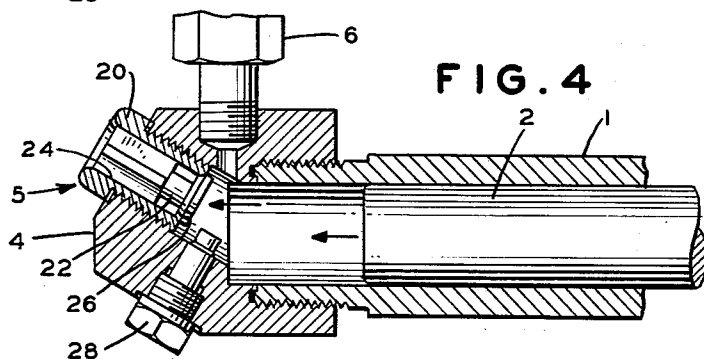
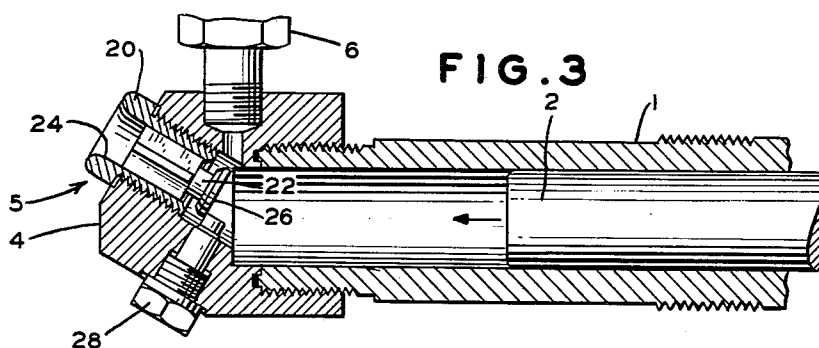
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LIQUEFIED GAS PUMP

Laurel E. Putman, Livingston, N.J., assignor to Superior Air Products Co., Newark, N.J., a corporation of Delaware

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This invention relates to apparatus for pumping volatile liquids and particularly to pumps for pumping liquefied gases which have boiling point temperatures, at atmospheric pressure, below 273° K., such as liquid oxygen, nitrogen, argon, and the like, against relatively high heads of pressure, for example, against a head of pressure up to 5000 pounds per square inch gauge.

Pumping of liquefied gases such as oxygen, nitrogen and argon against high pressures involves many difficulties due to the properties inherent in the highly volatile liquids, particularly with respect to the tendency of such liquefied gas to vaporize. In an effort to overcome some of these difficulties, pumps enclosed in a container of liquefied gas for pumping the liquid, as needed, have been used but, since such pumps have been dependent on pressure differential to open the inlet valve to feed the liquefied gas from the container into the pump, these pumps have not been completely satisfactory. This is particularly the case where the liquefied gas in the container is maintained at a pressure and temperature near the point of vaporization. Due to the relative instability of the gaseous material in its liquefied form, the decrease in pressure required to open the intake valve causes the liquefied gas to boil or flash into a vapor as it enters the pump chamber and either completely vapor binds the pump or, where vapor binding is not complete, renders the pump inefficient.

This invention has for its object the provision of an improved construction and arrangement of parts for pumps of the character indicated for achieving higher efficiency in operation to the extent that loss of volumetric efficiency due to gas binding is reduced to a minimum in a simple and expeditious manner.

It is a further object of the invention to provide a pump for pumping such volatile liquids from a reservoir which is relatively independent as to degree of enclosed volume, distance of main source from pump reservoir, amount and efficiency of insulation surrounding pump reservoir and liquid lines leading thereto from main source and the degree of sub-cooling of the volatile liquid.

These and other objects of the invention will be more apparent from consideration of the following description taken in connection with the accompanying drawings, in which:

FIG. 1 is a plan view of the pump assembly, partly in section, embodying the principles of the invention;

FIG. 2 is a view of the valve assembly along the lines 2—2 of FIG. 1;

FIG. 3 is a plan view of the pump and valve assembly of FIG. 1 showing the plunger and the intake valve at the beginning of the compression stroke;

FIG. 4 is a plan view of the pump and valve assembly of FIG. 1 showing the plunger and the intake valve assembly on the compression stroke at the point where the intake valve closes;

FIG. 5 is a plan view of the pump and valve assembly of FIG. 1 showing the plunger and the intake valve at the beginning of the suction stroke; and

FIG. 6 is a plan view of the pump and valve assembly of FIG. 1 showing the plunger and the intake valve on the suction stroke at the point where the inlet valve opens.

Referring to FIG. 1, the pump consists of a horizontally disposed cylinder 1, having a plunger 2 mounted for

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reciprocating movement therein, the plunger 2 being driven by a crank mechanism, not shown, which may be of a variable speed or variable stroke type. At its outer or warm end, the bore of the cylinder 1 is enlarged and is provided with a suitable packing 3 for sealing the plunger 2 in the cylinder, and, at its inner or cold end, is provided with a cylinder head 4 having an inlet valve assembly 5 and a discharge valve line 6, the discharge valve line 6 containing a check valve 7.

At its inner or cold end, the pump assembly is surrounded by a liquid reservoir 8 which may be flanged to the pump cylinder flange 9 for ease of assembly. The entire cold end of the pump and the reservoir 8 are insulated from the ambient temperature by means of suitable mass or mass-vacuum insulation 10 contained within housing 11. The reservoir 8 is connected by conduit 12 to a liquid source, not shown, a vent line 14 connecting the reservoir back to the liquid source, preferably to the gas phase in the liquid source. Continued evolution of vapor takes place in the reservoir 8 due to heat leakage from the surroundings, either directly to the reservoir through the insulation 10 or through the pump cylinder 1 and plunger 2. Additional vapor is evolved by heat generated from the frictional contact between the plunger 2 and the packing 3 and cylinder 1 during reciprocating movement of plunger 2. This vapor is returned through the vent line 14 to the gas phase of the liquid source, or may be vented from the system, in order that the pump cylinder 4 and inlet valve assembly 5 be submerged in liquefied gas during operation.

The inlet valve assembly 5 consists of an insert 20, threaded or otherwise suitably attached in the cylinder head 4, and a valve 22, slidably mounted in the insert 20 on guides 24 projecting from the stem of the valve (FIG. 2). At its inner end, the valve 22 is provided with a head 26 having a seat on its inner face for seating engagement with a mating seat on the insert 20. When open, the valve 22 contacts stop 28 threaded into the head 4, the stop 28 limiting the inward opening movement of the valve.

As best shown in FIG. 1, the cylinder 1 and plunger 2 are positioned horizontally in the reservoir 8, the plunger 2 being mounted in the cylinder 1 for horizontal reciprocal movement in the cylinder by a crank mechanism, not shown. The inlet valve assembly 5 is angularly positioned in the cylinder head 4 so that the port formed in the compression chamber by the insert 20 is lower than the port at the opposite end of the insert formed in the reservoir. Thus, due to the angular position of the insert 20, the valve 22 is biased by gravity to an open position, the inward movement of the valve being limited by stop 28. For reasons more apparent hereinafter, it is preferred to position the inlet valve assembly so that the upper edge of the inlet port formed by the insert 20 in the compression chamber is in line with or slightly higher than the upper edge of the compression chamber.

In operation, liquefied gas is delivered from a supply source to the reservoir 8 through conduit 12. It is not necessary that the reservoir be filled but only that sufficient liquid be delivered to the reservoir to maintain the liquid level in the reservoir above the upper end of the inlet valve assembly 5. The supply of liquid to the reservoir 8 may be controlled in various manners, such as by regulating the flow through the conduit 12, by the use of a float in the reservoir 8 to control the discharge of the conduit 12 into the reservoir or by the use of a float in the reservoir to control the vent line 14 in a manner similar to that shown in U.S. Patent 2,500,320 dated March 14, 1950. Since the valve 22 is biased to an open position by gravity, as liquid is delivered into reservoir 8, the liquid will flow downward through the open inlet valve 22 and fill the compression chamber at the end of the cylinder

1. If the temperature of the cylinder 1 and plunger 2 is elevated at the time the liquefied gas is delivered into the reservoir, as the liquefied gas enters the compression chamber some vaporizing may take place. Due to the difference in density between the liquefied gas and the vapor, the vapor being lighter rises to the top of the compression chamber and escapes through the inlet port back into the reservoir, the space vacated by the vapor being filled with liquid. With the compression chamber thus filled, the plunger 2 may be moved either to the right, as shown in FIG. 1, in which event additional liquid will flow into the cylinder, or to the left, as shown in FIG. 1, in which event the inwardly moving plunger raises the level of the liquid in the compression chamber, forcing any vapor remaining in the chamber outward through the open intake valve, until the liquid impinges upon the intake valve face and, due to its density and relative incompressibility, forces the intake valve closed. With the intake valve closed, as the plunger continues its inward movement, liquid is forced through the check valve 7 and discharge line 6.

Referring now to FIG. 3, the plunger 2 is shown at the end of the suction stroke, or at the position where the plunger 2 is starting to move toward the cylinder head 4. In this position of the plunger 2, the valve 22 is open. Due to the heat evolved in the cylinder 1 and plunger 2 by friction and the heat of compression during the preceding compression stroke, some of the liquefied gas may have vaporized as it entered the cylinder during the intake or suction stroke. Since the vapor is less dense than the liquefied gas, the vapor rises to the top of the cylinder and is free to escape from the cylinder back into the reservoir through the angularly positioned insert 20. This escape occurs as the vapor forms and continues until the cylinder is substantially filled with liquefied gas. Should there be any vapor in the cylinder as the plunger commences the compression stroke, the vapor is first forced into the reservoir through the insert 20 before the intake valve 22 closes, the density of the escaping gas being insufficient to overcome the gravitational force holding the valve 22 in its open position. As the plunger 2 continues its movement toward the head 4, the liquid level in the cylinder is raised until the liquid is forced into contact with the head of valve 22 and, because of its density and relative incompressibility, forces the inlet valve to the closed position as shown in FIG. 4. With the intake valve 22 closed, the plunger continues to move toward the head 4 forcing the liquefied gas through the conduit 6 and out through the valve 7.

As shown in FIG. 5, when the plunger reaches the end of the compression stroke, the intake valve 22 is closed and all of the liquefied gas has been forced from the cylinder into the conduit 6 except for that relatively small quantity remaining in the cylinder as a result of the clearance between the end of the plunger 2 and the head 4. As the plunger moves away from the head 4 at the start of the suction or intake stroke, the force of the liquefied gas holding the intake valve closed is released and the valve opens. Since the valve is biased to the open position by gravity, there is no force to be overcome in order to open the valve. Hence, valve opening is instantaneous, any differential in pressure occasioned by the expansion of the liquefied gas remaining in the cylinder accelerating the opening of the valve before any substantial pressure differential and resulting vaporization occurs. As the plunger 2 moves away from the cylinder head 4 on the intake or suction stroke, when it reaches the point as shown in FIG. 6 the liquefied gas from the reservoir 8 flows through the open valve 22 filling the chamber formed in the cylinder by the withdrawing plunger, any vapor forming in the chamber rising to the top of the chamber and being vented therefrom back into the reservoir through the open and angularly disposed intake valve assembly.

As aforesaid, the intake valve assembly 5 is angularly positioned with respect to the cylinder 1 and plunger 2 so that the reservoir end of the port is higher than that

formed in the compression chamber. With the inlet valve assembly thus positioned, the inlet valve 22 is urged to the open position and only closes during the compression cycle of the pump, that is, when the plunger 2 moving inward in the cylinder 1 causes the liquid in the compression chamber to apply a direct force to the face of the valve to thereby move the valve to a closed position and hold the valve in such position only so long as the compression stroke continues. As soon as the compression cycle of the pump is completed the force holding the valve closed is released and the valve, under gravitational force, returns to its open position.

Various types of gravity-opened intake valves may be used so long as the movable valve member is provided with a face responsive to a fluid force applied thereagainst to close the valve. Due to its quick reaction to fluid force, a flat faced valve is preferred. As to the relative angular position of the inlet valve assembly, the passage formed by the inlet valve assembly from the compression chamber to the reservoir need only be progressively elevated toward the reservoir, the exact angle depending on the efficiency of inlet valve flow desired and vapor clearing required. An intake valve forming an enclosed angle of 165° with the horizontal axis of movement of the plunger has been found to provide the necessary gravitational force to assist in opening of the intake valve and, at the same time, provides an adequate vapor vent. Obviously, with various materials, port and valve sizes, other angular positions of the inlet valve assembly can be used. It suffices to say that the intake valve must tend to an open position by gravity, must allow for the escape of vapor from the chamber as the liquefied gas enters therein without closing and that fluid force resulting from inward movement of the plunger closes the valve.

The terms and expressions which have been employed are used as terms of description and not of limitation, and there is no intention, in the use of such terms and expressions, of excluding any equivalents of the features shown and described or portions thereof, but it is recognized that various modifications are possible within the scope of the invention claimed.

What is claimed is:

1. In apparatus for pumping a volatile liquid having a boiling point temperature below 273° K. at atmospheric pressure comprising a reservoir for containing a supply of such liquid, an elongated pump body having a pumping chamber therein adjacent one end and an opening at the other end, said pumping chamber being positioned in said reservoir, a reciprocable pumping element extending through said opening in the pump body and having an inner pumping end portion operable in said pumping chamber, a valve-controlled inlet port adjacent said pumping chamber, a valve-controlled outlet passage from the pumping chamber for liquid discharge, a packing means in said pump body adjacent its open end for sealing said reciprocable pumping element in said pumping body, and a valve in said inlet port, said valve being biased by gravity to an open position to allow vapor formed in said chamber to flow to said reservoir, and a head on said valve, said head forming a surface in said chamber against which the momentum of liquid in said chamber reacts to close said valve after said pumping element evacuates vapor from said chamber.

2. Apparatus for pumping a volatile liquid comprising a reservoir for containing a supply of such liquid, an elongated pump body having a pumping chamber therein adjacent one end and an opening at the other end, said pumping chamber being horizontally positioned in said reservoir, a reciprocable pumping element extending through said opening in the pump body and having an inner pumping end portion operable in said pumping chamber, a valve controlled inlet port forming a passage for the flow of liquid from said reservoir to said pumping chamber, a valve-controlled outlet passage from said pumping chamber for the passage of liquid therefrom, a

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packing means in said pump body adjacent its open end for sealing said pumping element for reciprocable movement therein, and a valve in said inlet port, said valve being biased by gravity to an open position to allow fluid to flow from said reservoir to said pumping chamber and to allow vapor formed in said chamber to flow to said reservoir, and a head on said valve, said head forming a surface against which the momentum of compressed liquid in said chamber reacts to close said valve after said pumping element evacuates vapor from said chamber.

3. Apparatus for pumping a volatile liquid comprising a reservoir for containing a supply of such liquid, an elongated pump body having a pumping chamber therein adjacent one end and an opening at the other end, said pumping chamber being horizontally positioned in said reservoir, a reciprocable pumping element extending through said opening in the pump body and having an inner pumping end portion operable in said pumping chamber, a valve controlled inlet port forming a passage for the flow of liquid from said reservoir to said pumping chamber, a valve-controlled outlet passage from said pumping chamber for the passage of liquid therefrom, a packing means in said pump body adjacent its open end for sealing said pumping element for reciprocable movement therein, and a valve in said inlet port, said valve being biased by gravity to an open position to allow fluid to flow from said reservoir to said pumping chamber and to allow vapor formed in said chamber to flow to said reservoir, and a head on said valve, said head forming a surface in said chamber against which the momentum of liquid in said chamber reacts to close said valve after said pumping element moving into said pumping chamber evacuates vapor from said chamber.

4. In apparatus for pumping a volatile liquid having a boiling point temperature below 273° K. at atmospheric pressure comprising a reservoir for containing a supply of such liquid, an elongated pump body having a pumping chamber therein adjacent one end and an opening at the other end, said pump body being horizontally positioned with said pumping chamber in said reservoir, a reciprocable pumping element extending through said opening in the pump body and having an inner pumping end portion operable in said pumping chamber, a valve controlled inlet port adjacent said pumping chamber, said inlet port providing a valve controlled opening adjacent the top of said pumping chamber, a valve controlled outlet passage from the pumping chamber for liquid discharge, a packing means in said pump body adjacent its open end for sealing said pumping element in said pumping body, a valve in said inlet port, said valve being gravity biased to an open position to allow volatile liquid to enter said pumping chamber and to vent vapor therefrom during movement of said pumping element away from said pumping chamber and to vent vapor from said chamber during initial movement of said pumping element toward said chamber, and a head on said valve, said head forming a surface in said chamber against which the momentum of liquid in said chamber reacts to close said valve after said pumping element moving toward said chamber evacuates vapor from said chamber.

5. In apparatus for pumping a volatile liquid having a boiling point temperature below 273° K. at atmospheric pressure comprising a reservoir for containing a supply of such liquid, an elongated pump body having a pumping chamber therein adjacent one end and an opening at the other end, said pump body being horizontally positioned with said pumping chamber in said reservoir, a reciprocable pumping element extending through said opening in the pump body and having an inner pumping end portion positioned for horizontal reciprocable movement in said pumping chamber, a valve controlled inlet port adjacent said pumping chamber, said inlet port being angularly positioned adjacent the top of said pumping chamber, a valve controlled outlet passage from the pumping chamber

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ber for liquid discharge, a packing means in said pump body adjacent its open end for sealing said pumping element in said pumping body, a valve in said inlet port, said valve being gravity biased to an open position to allow volatile liquid to enter said pumping chamber and to vent vapor therefrom during movement of said pumping element away from said pumping chamber and to vent vapor from said chamber during initial movement of said pumping element toward said chamber, and a head on said valve, said head forming a surface in said chamber against which the momentum of liquid in said chamber reacts to close said valve after the movement of said pumping element into said pumping chamber evacuates vapor from said chamber.

6. A pump for pumping a volatile liquid having a boiling point temperature below 273° K. at atmospheric pressure comprising a reservoir for containing a supply of such liquid, an elongated pump body having a pumping chamber therein adjacent one end and an opening at the other end, said pumping chamber being horizontally positioned in said reservoir, a reciprocable pumping element extending through said opening in the pump body and having an inner pumping end portion reciprocable in said pumping chamber, a valve controlled inlet port adjacent said pumping chamber, said inlet port forming an angularly disposed passage between said pumping chamber and said reservoir, said passage being elevated at said reservoir, a valve controlled outlet passage from the pumping chamber for liquid discharge, and a valve in said inlet port, said valve being biased by gravity to an open position to allow vapor formed in said chamber to flow to said reservoir, and a head on said valve, said head forming a surface in said chamber against which the momentum of fluid in said chamber reacts to close said valve after said pumping element moving into said pumping chamber evacuates vapor from said chamber.

7. Apparatus for pumping a liquefied gas having a boiling point below 273° K. at atmospheric pressure comprising an elongated pump body having a pumping chamber therein adjacent one end and an opening at the other end, a reciprocable pumping element extending through said opening and having an inner pumping end portion operable in said pumping chamber, a valve-controlled inlet port communicating with said pumping chamber for admitting liquefied gas thereto, a valve-controlled outlet passage communicating with said pumping chamber for liquid discharge, packing means for the portion of the pumping element passing through said opening, said packing means being spaced from said pumping chamber, a valve in said inlet port, a head on said valve, said valve being biased to an open position to allow liquefied gas to enter said pumping chamber during movement of said reciprocable pumping element away from said pumping chamber and to vent vaporized gas from said pumping chamber during initial movement of said reciprocable pumping element toward said pumping chamber, said head forming a surface in said chamber against which the momentum of liquid in said chamber reacts to close said valve after the movement of said pumping element toward said pumping chamber evacuates vapor from said chamber.

8. In apparatus for pumping a volatile liquid having a boiling point temperature below 273° K. at atmospheric pressure comprising a reservoir for containing a supply of such liquid, an elongated pump body having a pumping chamber therein adjacent one end and an opening at the other end, said pumping chamber being positioned in said reservoir, a reciprocable pumping element extending through said opening in the pump body and having an inner pumping end portion operable in said pumping chamber, a valve-controlled inlet port adjacent said pumping chamber, a valve-controlled outlet passage from the pumping chamber for liquid discharge, a packing means in said pump body adjacent its open end for sealing said reciprocable pumping element in said pumping body, a

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valve in said inlet port, a head on said valve, said valve being biased to an open position by gravity to allow liquid to enter said pumping chamber during movement of said reciprocable pumping element away from said pumping chamber and to vent vapor from said chamber during initial movement of said pumping element toward said chamber, said head forming a surface in said chamber against which the momentum of liquid in said chamber reacts to close said valve after the movement of said pumping element toward said pumping chamber evacuates vapor from said chamber.

9. A pump for pumping a volatile liquid having a boiling point temperature below 273° K. at atmospheric pressure comprising a reservoir for containing a supply of such liquid, a pump body having a pumping chamber therein adjacent one end and an opening at the other end, said pumping chamber being horizontally positioned in said reservoir, a reciprocable plunger extending through said opening in said pump body and having an inner pumping end portion reciprocable in said pumping chamber, a valve controlled inlet port adjacent said pumping chamber and forming an angularly disposed passage between said pumping chamber and said reservoir, said

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passage forming an opening in said reservoir spaced vertically above the opening formed by said passage in said pumping chamber to permit vapor to flow from said pumping chamber to said reservoir, a normally open valve in said passage to allow vapor formed in said chamber to flow to said reservoir, and a head on said valve, said head forming a surface in said chamber against which the momentum of liquid in said chamber reacts to close said valve as said pumping element moves said liquid after evacuating vapor from said chamber.

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