March 6, 1962 L. TYREE, JR 3,023,710

FLUID PUMPS

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Fig.1

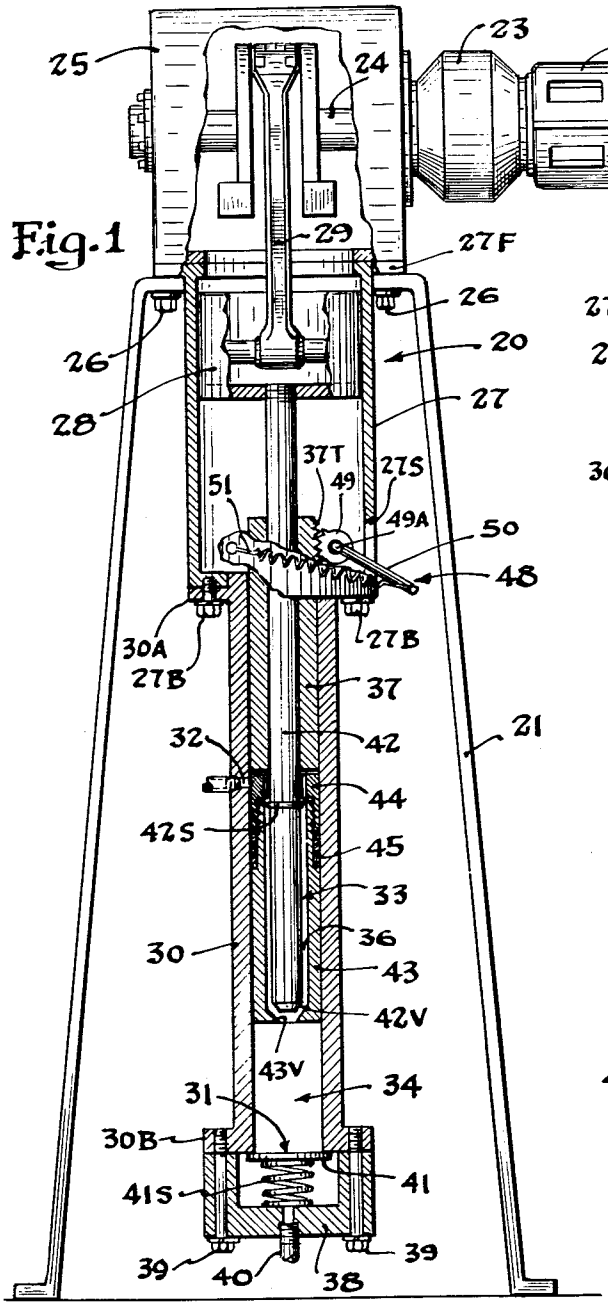
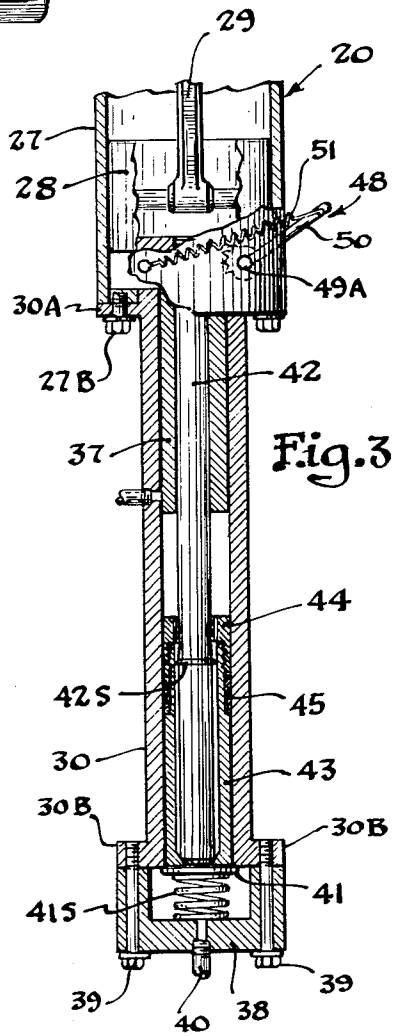


Fig.3



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Fig. 4

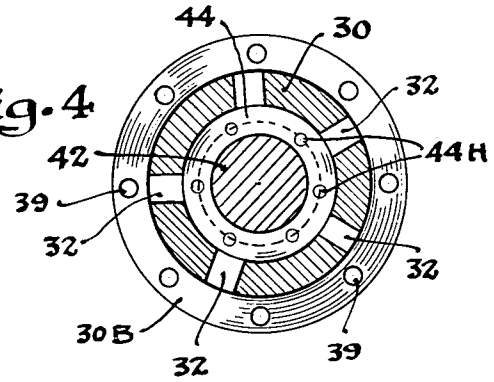


Fig. 2

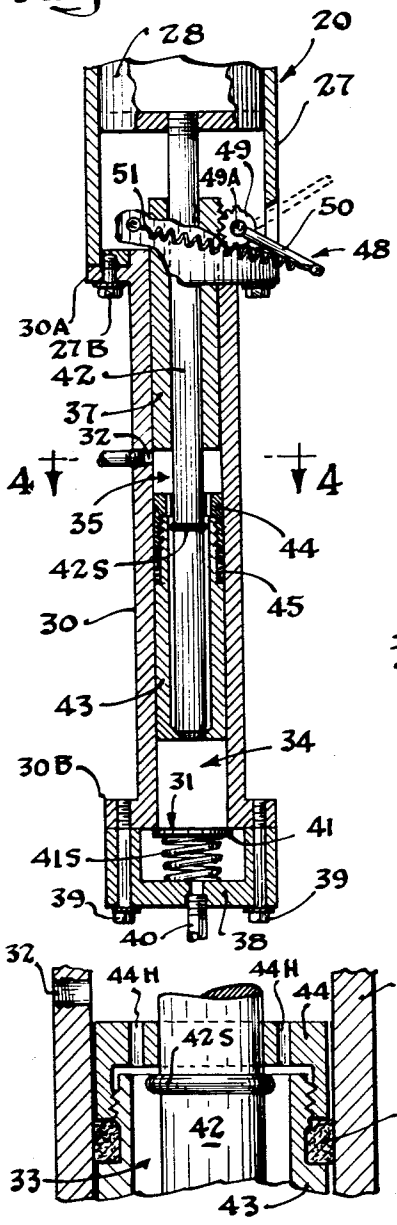
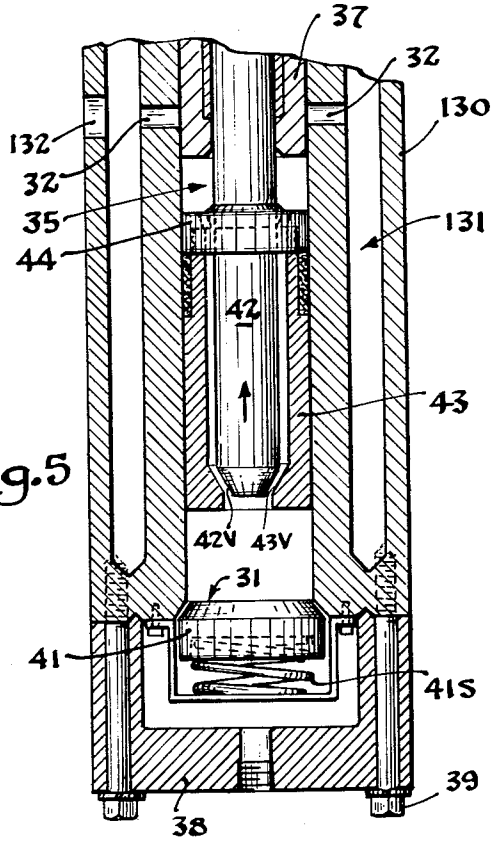


Fig. 6

Fig. 5



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FLUID PUMPS

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Fig.7

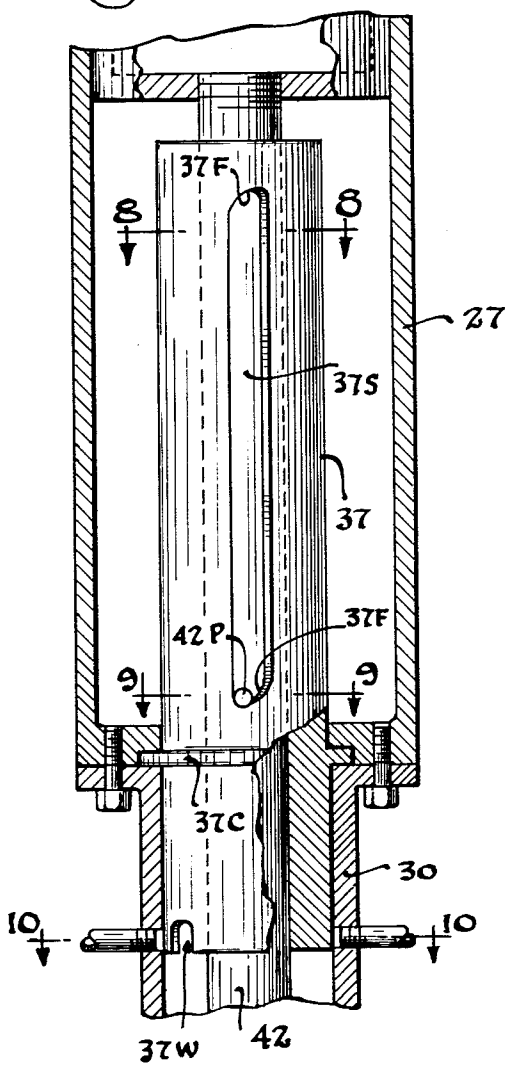


Fig.8

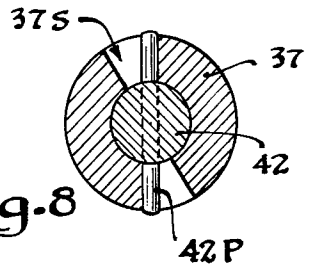


Fig.9

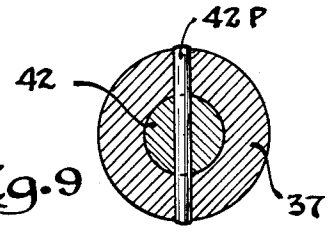
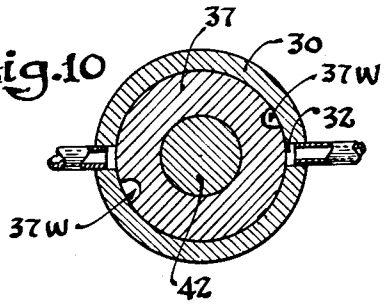


Fig.10



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3,023,710

FLUID PUMPS

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17 Claims. (Cl. 103—153)

This invention relates to fluid pumps and, more particularly, is concerned with pumps for transferring liquids which are at or substantially at their boiling point. The invention is also concerned with providing a pump construction capable of accurately metering the liquids or gases which it handles. The invention is further concerned with providing a pump construction in which the pumped fluid acts as its own lubricant.

The handling of liquids which are at or substantially at their boiling point involves a number of problems that have heretofore been difficult to eliminate. When subjected to suction, the boiling liquids tend to undergo a phase transition to a gaseous or vapor state, and this can cause vapor locking in the pumping system and can also lead to inaccuracy in metering. It will be apparent that as the boiling fluid is moved through the pumping system, its tendency to expand, compress, and re-expand must be properly controlled in order that it may be pumped with high efficiency. Different types of fluids have different compressibility characteristics, and in the various handling applications involving boiling liquids, varying inlet and discharge pressures are confronted, and these factors aggravate the inherently difficult task of handling a liquid which is at or substantially at its boiling point.

Liquid oxygen represents a typical application wherein it is necessary to transfer a boiling liquid from a low-pressure container to a high-pressure storage tank; and in general, it is necessary to accurately meter the quantity of liquid oxygen which is delivered from the container to the storage tank. In the prior art, the operation of pumps for use in handling liquid oxygen has been impaired by the tendency of the intake suction stroke to cause flashing to vapor of the boiling liquid which is to be introduced into the compression chamber. Spring-operated check type inlet valves have been used in prior art devices but have been unduly subject to vapor locking. Prior art pumps have difficulty with their inlet valves due to the difficulty of providing a valve of sturdy construction for spanning a large passage area.

The prior art pumps have also been inadequate for accurately metering the quantities of liquid oxygen transferred from a storage container at atmospheric pressure to a storage tank at a pressure of 2200 p.s.i. Another difficulty arises where the clearance volume remaining in the compression chamber is unduly large; re-expansion of the compressed fluid trapped in this clearance volume can seriously impair the accuracy of metering. In addition, the prior art pumps have suffered inaccuracies due to leakage through their inlet valve assembly and due to leakage past the power piston.

The present invention provides a pump construction that is free of the above-noted difficulties of prior art pumps, and the principal objects of the present invention are to provide a pump for transferring boiling liquids from low-pressure to high-pressure storage with high efficiency; to provide a pump capable of handling fluids with great volumetric accuracy; to provide a pump of the above type that is operable over varying conditions of inlet and discharge pressures and that is capable of accurately metering fluids of varying compressibilities; to provide a pump having a minimum clearance volume in its compression chamber and having provisions for eliminating leakage through its intake port and for controlling or trapping leakage from its compression chamber past its power piston to its suction chamber; and to provide a pump arrangement in which the volumetric displacement in the compression chamber is equal to or greater than that of the suction chamber for eliminating the possibility of two-staging.

Briefly, in a preferred constructional embodiment, the pump of the present invention utilizes a power piston mechanism reciprocable through a cylinder that has a compression chamber communicating with a discharge port at one end and that has an intake chamber communicating with an intake port that is spaced from the compression chamber, with the power piston mechanism having a fluid transfer passage extending therethrough to connect the compression chamber and the intake chamber. The power piston mechanism acts as a valve to seal this transfer passage during the compression stroke and to open the transfer passage during the return stroke for accomplishing a transfer to the compression chamber of the fluid that was drawn into and entrapped in the intake chamber during the compression stroke.

The motion of the power piston mechanism also controls the positioning of a sleeve that is shiftable between a position wherein it covers the intake port during the return stroke and a position wherein it uncovers the intake port during the compression stroke. This sleeve responds to the movement of the power piston mechanism for shifting from its port-closing position to its port-opening position at the end of the return stroke and for shifting from its port-opening position to its port-closing position at the end of the compression stroke.

This preferred arrangement has a number of advantageous features, some of which are that the intake into the pump is through ports controlled by a port-closing sleeve that is not required to hold or seal against high pressures. Positive filling of the high-pressure compression chamber is also provided, since the fluid which has been drawn into the intake chamber during the previous compression stroke is entrapped and then forced into the compression chamber during the return stroke. During the compression stroke, substantially all leakage occurring past the valve in the fluid-transfer passage and past the power piston mechanism is entrapped in the intake chamber and does not escape through the intake port. Many of these boiling liquids commonly encountered are not compatible with lubricants. This pump is particularly useful where the fluid itself has to act as its own lubricant, as will be seen later.

Other objects and advantages will become apparent during the course of the following description.

In the accompanying drawings forming a part of this specification and in which like numerals are employed to designate like parts throughout the same:

FIG. 1 is a front view, partly in elevation and partly in section, illustrating a preferred constructional embodiment of a complete pump mechanism of this invention and illustrating the position of the pumping elements at the beginning of the compression stroke;

FIG. 2 is a front sectional view illustrating the position of the pumping elements at an intermediate point of the compression stroke;

FIG. 3 is a front sectional view illustrating the position of the pumping elements at the end of the compression stroke;

FIG. 4 is an enlarged plan sectional view taken on the line 4—4 of FIG. 2 to better illustrate the intake port arrangement;

FIG. 5 is a fragmentary front sectional view illustrating an alternative cylinder casing construction with the parts being shown in the positions they assume at an intermediate point in the return stroke;

FIG. 6 is an enlarged sectional view better illustrating the details of the power piston mechanism;

FIG. 7 is a fragmentary sectional view illustrating a

pump arrangement having an intake port closure mechanism of alternative construction; and

FIGS. 8, 9 and 10 are detailed sectional views taken, respectively, on the lines 8—8, 9—9, and 10—10 of FIG. 7.

One important application for the present pump construction, that is shown herein for purposes of illustrative disclosure, involves the pumping of liquid oxygen from a refrigerated container in which it may be stored at atmospheric pressure to a dispensing tank in which it may be stored at a pressure on the order of 2200 p.s.i. The illustrated pumping arrangement is suitable for direct immersion in the refrigerated container or it may be provided with a suitable supporting stand for mounting the pump alongside the refrigerated container with intake conduits extending from the container to the pump intake.

In the usual application involving the pumping of liquid oxygen, it is important that the quantity of oxygen delivered through the pump be accurately measured, and it is therefore desirable that the pump function as a metering device.

Referring now to FIG. 1, the pump mechanism, which is designated in its entirety as **20**, is shown mounted on a supporting stand **21** for operation in a vertical position, this being a preferred arrangement, though, as will become apparent, the pump is capable of operation in other positions. As illustrated, the pump is preferably constructed as a portable unit assembly and it includes an electric motor **22** operable through a reduction drive **23** to rotate a crankshaft **24** journalled in a crankcase **25**, the bottom wall of which is fastened to the stand **21** by a plurality of bolts **26**.

A guide housing **27** for a crosshead **28** has an external mounting flange **27F** at its upper end sandwiched between the stand **21** and the crankcase **25** to mount the guide housing in depending relation within the center of the frame. A connecting rod **29** extends from the crankshaft **24** to drivingly connect the crosshead **28** for vertical reciprocation within the guide housing **27** under the control of the driving motor **22**.

The pumping elements are mounted to the bottom of the guide housing and crosshead and comprise a cylinder or casing **30** having a discharge port **31** opening through its lower end and an intake port **32** opening through the cylinder at a point spaced from the discharge port in the vertical or lengthwise direction of the cylinder; a power piston mechanism designated generally at **33** reciprocably slideable lengthwise in a portion of the cylinder that extends between the inlet and discharge ports to provide a compression chamber, indicated at **34** in FIG. 1, communicating with the discharge port, an intake chamber indicated at **35** in FIG. 2 communicating with the intake port, and a fluid-transfer passage **36** extending through the power piston mechanism to connect the compression and intake chambers; and a sleeve **37** shiftable between its FIG. 3 position wherein it covers the intake port **32** and its FIG. 1 position wherein it uncovers the intake port.

The cylinder **30** is provided with upper and lower attachment flanges **30A** and **30B**, respectively, with the upper end of the cylinder being secured to the bottom of the guide housing **27** by a plurality of bolts **27B** which are passed through the attachment flanges **30A**. A valve cover housing **38** is secured to the attachment flange **30B** at the bottom of the cylinder by a plurality of bolts **39** and the valve cover housing **38** is fitted with a discharge conduit **40** leading to the tank to which the liquid oxygen is to be delivered. A disc type discharge valve **41** for the discharge port **31** is yieldably held seated by a valve spring **41S** to control the discharge from the compression chamber **34**.

The power piston mechanism **33** comprises a piston rod **42** fixed to and jointly movable with the vertically reciprocating crosshead **28** and a power piston assembly that is confined loosely over the free end of the piston rod to establish and control the fluid-transfer passage **36**. The power piston assembly comprises a piston sleeve **43** fitted over the lower end of the piston rod **42** to function jointly therewith as a power piston and a mating, locking sleeve **44** fitted over the upper end of the piston rod and threadedly secured to the piston sleeve for compressing a seal ring **45** (see FIG. 6) of high-pressure packing therebetween. To provide the fluid-transfer passage through the power piston mechanism, the piston sleeve is given an internal diameter greater than the external diameter of the piston rod, with a series of holes **44H** (FIG. 6) being provided to extend this passage through the locking sleeve **44**.

As best seen in FIG. 6, the piston rod **42** has an external abutment shoulder **42S** for engagement against the underneath side of the locking sleeve **44** to return the power piston assembly on the up-stroke of the piston rod. At its lower end the piston rod has a bevelled end providing an annular external valve seat surface **42V** for mating engagement with a corresponding annular internal valve seat surface **43V** provided at the lower end of the piston sleeve. These valve seat surfaces engage during the compression stroke to drive the piston sleeve downwardly jointly with the piston rod and to block the transfer passage **36** and interrupt communication between the intake and compression chambers. Engagement between the surfaces is arranged to present a flat, composite piston face (see FIG. 2) in order to reduce the clearance volume of the high-pressure compression chamber. Alignment of the piston rod with the cylinder **30** is also important, and the bevelled valve seat arrangement gives the piston rod a self-centering action during its compression stroke. Since the piston sleeve assembly is confined loose on the end of the piston rod, the valve surfaces **42V** and **43V** which are engaged during the compression stroke to close off the transfer passage **33** are spaced apart slightly during the return stroke, this relationship being shown in FIG. 5.

The shiftable sleeve **37** which is provided for controlling the intake port is mounted as a free piston within the upper end of the cylinder and its shifting movements are triggered by the motion of the piston rod **42**. As the end of the compression stroke is reached, the crosshead **28**, which moves jointly with the piston rod, strikes the upper end of the floating sleeve **37** to force it downwardly from its port-opening position to its port-closing position. At the end of the return stroke, the locking sleeve **44**, which rides upwardly with the shoulder **42S** on the piston rod, strikes the lower end of the floating sleeve, and upon continued movement, drives the sleeve from its port-closing position to its port-opening position.

An overcenter spring assembly, designated generally at **48**, is provided for yieldably resisting accidental shifting of the floating sleeve **37** to ensure that it will remain in the position to which it is driven by the motion of the piston rod. The upper end of the floating sleeve projects within the guide housing **27** and is provided with rack teeth **37T** along its upper section. An internal pawl **49** is mounted on an axle **49A** that is journalled in the guide housing and has peripheral teeth **49T** meshing with the rack teeth on the floating piston for translating shifting movement of the piston into swinging movement of a guide arm **50** that is carried by the pawl. The guide arm projects through a slot **27S** provided in the guide housing and is engageable with the housing surfaces bordering the opposite ends of the slot to limit the movement of the pawl. External bias springs **51** on opposite sides of the guide housing are connected to the outer end of the guide arm **50**. In FIG. 1 the guide arm is swung downwardly and the bias springs **51** act to resist upward swinging movement of the guide arm **50**. However, these springs yield to accommodate downward shifting of the floating piston during the compression stroke of the piston rod. During downward movement of the floating piston, its rack teeth drive the pawl to swing the guide arm to the

position in which it is shown in FIG. 3. In this position the bias springs **51** resist upward shifting of the floating piston. Thus, the action of the overcenter spring assembly tends to hold the floating piston stationary in either its port-closing or port-opening position.

For maximum pumping efficiency, the intake porting arrangement should allow a rapid flow of the liquid oxygen into the intake chamber **35**. The detailed sectional view of FIG. 4 illustrates that a number of intake ports **32** may be provided through the walls of the cylinder **30** to feed into the intake chamber on all sides. This arrangement is particularly useful if the pump is to be submerged in the liquid oxygen, but it may also be used with a plurality of connection hoses leading from the liquid oxygen to the intake ports.

FIG. 5 illustrates a manifold type cylinder casing **130** having hollow surrounding wall structure defining a manifold chamber **131** for connecting a single intake opening **132** for feeding through a plurality of intake ports **32**. Such an arrangement is particularly useful where the liquid oxygen is fed to the pump through a single hose.

Operation

The functioning of the pumping elements and the advantages of the arrangement of the present invention will become more apparent from the following detailed description of a typical operating sequence. The operating cycle may be described beginning with FIG. 1 wherein the crosshead **28** is in the top dead center position. As the crosshead moves downwardly, the piston rod **42** moves downwardly a corresponding distance, while the floating piston **37** remains in its illustrated position under the influence of the overcenter spring mechanism **48**. During the initial movement, the shoulder **42S** on the piston rod moves free from supporting engagement beneath the locking sleeve **44** until the bevelled valve surface **42V** of the piston rod seats in the mating bevelled valve surface **43V** of the piston sleeve.

During further downward movement, the piston rod and piston sleeve move as a unit; and as the intake chamber **35** expands, fluid flows through the intake ports to begin filling the intake chamber. This filling action continues as the crosshead moves down toward bottom dead center.

As the crosshead approaches bottom dead center position, its lower surface strikes the upper end of the floating piston to shift it from its port-opening position (see FIGS. 1 and 2) to its port-closing position. When the crosshead is at bottom dead center, the floating piston is in its port-closing position (see FIG. 3).

Upon initial upward movement of the crosshead from its bottom dead center position, the power piston sleeve assembly remains stationary while the piston rod **42** moves upwardly until its shoulder **42S** engages and lifts the sleeve assembly. This permits the valve seat surfaces **42V** and **43V** to disengage and establish communication between the intake chamber and the compression chamber. The liquid entrapped in the intake chamber during the previous compression stroke is forced through the transfer passage **36** as the piston sleeve **43** is drawn upwardly with the piston rod. Towards the end of this return stroke, the upper face of the locking sleeve **44** strikes the lower end of the floating piston **37** to forcibly shift the floating piston into its port-opening position against the initial resistance of the overcenter spring assembly. The lifting motion of the floating piston drives the overcenter spring assembly from the position in which it is shown in FIG. 3 to the position in which it is shown in FIG. 1.

Now, as the crosshead moves downwardly from its top dead center position and drives the piston rod **42** downwardly to seat its lower end against the piston sleeve and thereafter move as a unit with the piston sleeve, fluid again flows through the intake ports to being filling the intake chamber, as described above. At the same time, the liquid that was trapped in the intake chamber **35** during the previous compression stroke and that was transferred to the high-pressure compression chamber **34** during the previous return stroke of the piston rod is now compressed in the compression chamber by the downward force exerted by the power piston mechanism. This action continues until the pressure within the compression chamber becomes great enough to overcome the discharge pressure and the supplementing force of the valve spring **41S**. The discharge valve **41** then opens and during further downward motion of the power piston mechanism the compressed fluid is forced through the discharge conduit **40**.

Towards the end of the compression stroke, the crosshead strikes the floating piston to shift it from its port-opening to its port-closing position and as the crosshead reaches its bottom dead center position, the discharge valve again closes. The succeeding stages of operation are repetitive and will be apparent from the foregoing description. Since the compression chamber **34** occupies the full cross-section of the cylinder **30** while the intake chamber **35** occupies only the annular section of the cylinder that surrounds the piston rod **42**, it will be appreciated that the volumetric displacement of the compression chamber is greater than that of the intake chamber. This arrangement insures that the fluid entrapped in the intake chamber can be transferred to the compression chamber without having to develop any pressure head in the intake chamber except for that which is necessary to overcome friction losses. Thus this relationship prevents two-staging, and the elimination of two-staging relieves the floating sleeve **37** from holding the intake ports closed against any significant pressure differential.

Since the compression chamber reaches its discharge pressure only during the end of the stroke, after the floating piston **37** has shifted to close the inlet ports, the principal leakage through and around the power piston mechanism is only to the intake chamber and not to atmosphere or back through the inlet ports. Thus, the leakage around the power piston can act as the lubricant, yet is not lost to the system. The leakage rate can be adjusted by the closeness of fit to accommodate varying fluid, pressure, and temperature conditions. Further, the relationship of stroke, volume of intake chamber and volume of compression chamber can be varied to accommodate varying leakage rates. If necessary, the intake chamber can increase in volume to accommodate this leakage by exerting a force on the floating sleeve **37** and moving the overcenter spring mechanism slightly, but yet not open the intake ports.

For best operation, attention should be directed to a number of constructional features. In order to minimize the clearance volume of the high-pressure chamber, the lower end of the piston rod seats flush with the end of the piston sleeve to provide a flat, composite piston face that is movable to a position immediately adjacent the discharge valve. This minimizes the clearance volume of the compression chamber. The self-centering engagement between the piston sleeve **43** and the piston rod **42** insures that the plane of travel of the piston rod is parallel to the direction of the cylinder. In the optimum arrangement, the end of the piston rod seats exactly centrally within the piston sleeve **43**; and the guide bore through the floating piston **37** through which the piston rod is reciprocated is concentric with the outer surface of the floating piston. To provide a minimum clearance volume for the intake chamber, the upper face of the locking sleeve **44** is made exactly parallel with the adjacent lower face of the floating piston. In addition, the floating piston should be accurately machined for a snug sliding fit within the cylinder in order to develop a good closing action across the intake ports.

Modification

In FIGS. 7–10, a modified floating sleeve arrangement is illustrated wherein the floating sleeve **37** is provided with registering elongated slots **37S** extending lengthwise on opposite sides of its upper end. This upper end

section of the floating sleeve is located within the crosshead guide housing 27 which is correspondingly vertically elongated to accommodate this construction. The floating sleeve has an annular external thrust collar 37C confined within an annular recess provided in the base of the guide housing to support the sleeve against lengthwise or vertical movement while accommodating rotational movement thereof.

In this construction, the piston rod 42 is provided with a cross pin 42P having its opposite ends projecting into the slots 37S of the floating sleeve. The slots 37S have a length corresponding generally to the travel stroke of the piston rod and the opposite ends of the slots are bordered by oppositely acting cam faces 37F which are engageable with the cross pin 42P of the piston rod to translate its vertical movement into rotational movement of the floating sleeve 37. The lower end of the sleeve projects beneath the plane of the intake ports 32 and is provided with wall openings 37W (FIGS. 7 and 10) for registry with the intake ports when the sleeve 37 is in its port-opening position.

In FIG. 7, the floating sleeve is shown in its port-closing position, which is the position to which it shifts as the piston rod reaches bottom dead center position. Upon upward movement of the piston rod, its cross pin 42P moves freely in the slots 37S without altering the position of the floating sleeve until the last increment of travel wherein the pin contacts the upper cam face 37F and imparts a twisting or rotational movement to shift the sleeve into its port-opening position. A similar but reverse movement occurs at the end of the compression stroke.

It will be apparent that the objects of the invention have been accomplished in that the pump construction illustrated herein is capable of pumping fluids with great volumetric accuracy and is capable of handling liquids which are at, or substantially at, their boiling points with high efficiency. The pump construction preferably utilizes an arrangement wherein the high-pressure compression chamber has a greater volumetric displacement than the intake chamber for avoiding two-staging. The intake to the pump is through ports controlled by a floating sleeve which is positioned in accordance with the motion of the piston rod.

The foregoing description and the drawings are given merely to explain and illustrate the invention and the manner in which it may be performed, and the invention is not to be limited thereto except insofar as the appended claims are so limited, since those skilled in the art who have this disclosure before them will be able to make modifications and variations therein without departing from the scope and spirit of the invention.

I claim:

1. A fluid pump comprising a casing providing a cylinder having opposed ends and extending lengthwise between said ends, a discharge port opening into one end of said cylinder, an intake port opening into said cylinder at a point spaced from said discharge port in the lengthwise direction of said cylinder, a pressure-responsive discharge valve normally closing said discharge port, means including a sleeve sealingly slideable lengthwise within a portion of said cylinder that extends between said inlet and discharge ports and a piston rod slideable through the other end of said cylinder and through said sleeve to define in said cylinder a compression chamber communicating with said discharge port, an intake chamber communicating with said intake port and a fluid passage connecting said compression and intake chambers, said sleeve and piston rod having cooperating surfaces engageable in response to compression movement of said rod to block said passage and to move said sleeve towards said discharge port and having cooperating surfaces engageable in response to return movement of said rod to move said sleeve towards said intake port, and means including a shiftable member for said intake port responsive to compression movement of said piston rod for moving said shiftable member to port-closing position at the end of said compression movement and responsive to return movement of said piston rod for moving said shiftable member away from port-closing position at the end of said return movement.

2. A fluid pump comprising a casing providing a cylindrical chamber having opposed ends and extending lengthwise between said ends, a discharge port opening into one end of said chamber, and an intake port opening into said chamber at a point spaced from said discharge port in the lengthwise direction of said chamber, a pressure-responsive discharge valve normally closing said discharge port, means including a sleeve sealingly slideable lengthwise within a portion of said housing that extends between said inlet and discharge ports and a piston rod slideable through the other end of said chamber and through said sleeve to define in said chamber a compression chamber communicating with said discharge port, an intake chamber communicating with said intake port and a fluid passage connecting said compression and intake chambers, said sleeve and piston rod having cooperating surfaces engageable in response to compression movement of said rod to block said passage and to move said sleeve towards said discharge port and having cooperating surfaces engageable in response to return movement of said rod to move said sleeve towards said intake port, and means including a shiftable member for said intake port responsive to compression movement of said piston rod for moving said shiftable member to port-closing position at the end of said compression movement and responsive to return movement of said piston rod for moving said shiftable member away from port-closing position at the end of said return movement.

3. A fluid pump comprising a casing providing a cylinder having opposed ends and extending lengthwise between said ends, a discharge port opening into one end of said cylinder, an intake port opening into said cylinder at a point spaced from said discharge port in the lengthwise direction of said cylinder, a pressure-responsive discharge valve normally closing said discharge port, means including a piston rod slideable through the other end of said cylinder to define in said cylinder a compression chamber communicating with said discharge port, an intake chamber communicating with said intake port and a fluid passage connecting said compression and intake chambers, means responsive to compression movement of said rod to block said passage and to expand said intake chamber and responsive to return movement of said rod to open said passage and to contract said intake chamber, and means including a shiftable member for said intake port responsive to compression movement of said piston rod for moving said shiftable member to port-closing position at the end of said compression movement and responsive to return movement of said piston rod for moving said shiftable member away from port-closing position at the end of said return movement.

4. A fluid pump comprising a casing providing a cylinder having opposed ends and extending lengthwise between said ends, a discharge port opening into one end of said cylinder, an intake port opening into said cylinder at a point spaced from said discharge port in the lengthwise direction of said cylinder, a pressure-responsive discharge valve normally closing said discharge port, means including a piston rod slideable through the other end of said cylinder to define in said cylinder a compression chamber communicating with said discharge port, an intake chamber communicating with said intake port and a fluid passage connecting said compression and intake chambers, means responsive to compression movement of said rod to block said passage and to expand said intake chamber and responsive to return movement of said rod to open said passage and to contract said intake chamber, and means including a floating sleeve projecting through said other end of said cylinder and surround-

ing said piston rod for shifting movement between a position wherein it opens said intake port and a position wherein it closes said intake port and responsive to compression movement of said piston rod for moving said shiftable sleeve from port-opening to port-closing position at the end of said compression movement and responsive to return movement of said piston rod for moving said shiftable sleeve from port-closing to port-opening position at the end of said return movement.

5. A fluid pump comprising a casing providing a cylinder having opposed ends and extending lengthwise between said ends, a discharge port opening into one end of said cylinder, an intake port opening into said cylinder at a point spaced from said discharge port in the lengthwise direction of said cylinder, a pressure-responsive discharge valve normally closing said discharge port, means including a sleeve sealingly slideable lengthwise within a portion of said cylinder that extends between said inlet and discharge ports and a piston rod slideable through the end of said cylinder and through said sleeve to define in said cylinder a compression chamber communicating with said discharge port, an intake chamber communicating with said intake port, and a fluid passage connecting said compression and intake chambers, said sleeve and piston rod having cooperating surfaces engageable after initial compression movement of said rod to block said passage and to move said sleeve towards said discharge port during further compression movement of said rod and having cooperating surfaces engageable after initial return movement of said rod unblocks said passage to move said sleeve towards said intake port during further return movement of said rod, and means including a shiftable sleeve encircling said piston rod for movement between a position wherein it opens said intake port and a position wherein it closes said intake port and responsive to compression movement of said piston rod for moving said shiftable sleeve from port-opening to port-closing position at the end of said compression movement and responsive to return movement of said piston rod for moving said shiftable sleeve from port-closing to port-opening position at the end of said return movement.

6. A fluid pump comprising a cylinder having opposed ends and extending lengthwise therebetween, a discharge port opening into one end of said cylinder, an intake port opening into said cylinder at a point spaced from said discharge port in the lengthwise direction of said cylinder, a pressure-responsive discharge valve normally closing said discharge port, means including a piston rod slideable through the other end of said cylinder and defining in said cylinder a compression chamber between the end of said piston rod and said one end of said cylinder, an intake chamber communicating with said intake port and having less volumetric displacement than said compression chamber and a fluid passage connecting said compression and intake chambers, means responsive to compression movement of said rod to block said passage and to expand said intake chamber and responsive to return movement of said rod to open said passage and to contract said intake chamber, and means including a shiftable member for said intake port responsive to compression movement of said piston rod for moving said shiftable member to port-closing position at the end of said compression movement and responsive to return movement of said piston rod for moving said shiftable member away from port-closing position at the end of said return movement.

7. A fluid pump comprising a cylinder having opposed ends and extending lengthwise therebetween, a discharge port opening into one end of said cylinder, an intake port opening into said cylinder at a point spaced from said discharge port in the lengthwise direction of said cylinder, a pressure-responsive discharge valve normally closing said discharge port, means including a sleeve sealingly slideable lengthwise within a portion of said cylinder that extends between said inlet and discharge ports and a piston rod slideable through the end of said cylinder and through said sleeve to define a compression chamber between the adjacent ends of said piston rod and said sleeve and said one end of said cylinder, an intake chamber communicating with said intake port and having less volumetric displacement than said compression chamber and a fluid passage connecting said compression and intake chambers, said sleeve and piston rod having cooperating surfaces engageable after initial compression movement of said rod to block said passage and to move said sleeve towards said discharge port during further compression movement of said rod and having cooperating surfaces engageable after initial return movement of said rod unblocks said passage to move said sleeve towards said intake port during further return movement of said rod, and means including a shiftable sleeve encircling said piston rod for movement between a position wherein it opens said intake port and a position wherein it closes said intake port and responsive to compression movement of said piston rod for moving said shiftable sleeve from port-opening to port-closing position at the end of said compression movement and responsive to return movement of said piston rod for moving said shiftable sleeve from port-closing to port-opening position at the end of said return movement.

8. A fluid pump comprising a cylinder having opposed ends and extending lengthwise therebetween, a discharge port opening into one end of said cylinder, an intake port opening into said cylinder at a point spaced from said discharge port in the lengthwise direction of said cylinder, a pressure-responsive discharge valve normally closing said discharge port, means including a piston sleeve sealingly slideable lengthwise within a portion of said cylinder that extends between said inlet and discharge ports and a piston rod slideable through the other end of said cylinder and through said piston sleeve to define in said cylinder a compression chamber communicating with said discharge port, an intake chamber communicating with said intake port and a fluid passage connecting said compression and intake chambers, a shiftable sleeve within said cylinder and encircling said piston rod for movement lengthwise in said cylinder between a position wherein it opens said intake port and a position wherein it closes said intake port, said piston sleeve and piston rod having cooperating surfaces engageable after initial compression movement of said rod to block said passage and to move said piston sleeve towards said discharge port during further compression movement of said rod and having cooperating surfaces engageable after initial return movement of said rod unblocks said passage to move said piston sleeve beyond said intake port during further return movement of said rod to move said shiftable sleeve from port-closing to port-opening position at the end of said return movement, and means responsive to compression movement of said piston rod for moving said shiftable sleeve from port-opening to port-closing position at the end of said compression movement.

9. A fluid pump comprising a cylinder having opposed ends and extending lengthwise therebetween, a discharge port opening into one end of said cylinder, an intake port opening into said cylinder at a point spaced from said discharge port in the lengthwise direction of said cylinder, a pressure-responsive discharge valve normally closing said discharge port, means including a piston sleeve sealingly slideable lengthwise within a portion of said cylinder that extends between said inlet and discharge ports and a piston rod slideable through the other end of said cylinder and through said piston sleeve to define in said cylinder a compression chamber communicating with said discharge port, an intake chamber communicating with said intake port and a fluid passage connecting said compression and intake chambers, a shiftable sleeve projecting through the other end of said cylinder and encircling said piston rod for movement rotationally in said cylinder between a position wherein it opens said intake port and a position wherein it closes said intake port,

said last-named sleeve and said piston rod having cooperating camming surfaces engageable at the end of said compression movement of said piston rod for rotating said last-named sleeve from port-opening to port-closing position and engageable at the end of said return movement of said rod to rotate said last-named sleeve from port-closing to port-opening position.

10. A fluid pump comprising a cylinder having opposed ends and extending lengthwise therebetween, a discharge port opening into one end of said cylinder, an intake port opening into said cylinder at a point spaced from said discharge port in the lengthwise direction of said cylinder, a pressure-responsive discharge valve normally closing said discharge port, a power piston mechanism including a piston rod slideable through the other end of said cylinder, and a piston sleeve loosely engaged in encircling relation around the end of the piston rod disposed in said cylinder for movement therewith towards and away from said one end of said cylinder to define in said cylinder a compression chamber therebetween communicating with said discharge port, an intake chamber communicating with said intake port and a fluid passage connecting said compression and intake chambers, said sleeve and piston rod having cooperating surfaces engageable after initial compression movement of said rod to block said passage and to move said sleeve towards said discharge port during further compression movement of said rod and having cooperating surfaces engageable after initial return movement of said rod unblocks said passage to move said sleeve towards said intake port during further return movement of said rod, and means including a shiftable sleeve encircling said piston rod for movement between a position wherein it opens said intake port and a position wherein it closes said intake port and responsive to compression movement of said piston rod for moving said shiftable sleeve from port-opening to port-closing position at the end of said compression movement and responsive to return movement of said piston rod for moving said shiftable sleeve from port-closing to port-opening position at the end of said return movement.

11. A fluid pump comprising a cylinder having inlet and discharge ports spaced apart lengthwise therealong, a sleeve sealingly slideable within a portion of the cylinder that extends between said inlet and discharge ports, said sleeve having an internal abutment shoulder at the end thereof adjacent the inlet port and having an internal valve seat surrounding a fluid opening at the end thereof adjacent said discharge port, a piston rod slideable through said cylinder and said sleeve and having a fluid-contacting face at the end thereof adjacent the discharge port, said rod and said sleeve defining therebetween a lengthwise fluid passage opening through opposite ends of said sleeve, said rod having a valve surface to establish sealing engagement with said seat and block said passage during movement of said rod towards said discharge port, said rod and said sleeve having cooperating shoulders interengageable after initial movement of said piston rod away from said discharge port to unblock said passage for moving said sleeve with said rod during further movement of said piston rod away from said discharge port, shiftable means for closing said inlet port, reversible actuating means responsive to final movement of said rod towards said discharge port for moving said shiftable means to port-closing position and responsive to final movement of said rod away from said discharge port for moving said shiftable means away from port-closing position, means including a pressure-responsive discharge valve for said discharge port to define a compression chamber in said cylinder, and means for reciprocating said piston rod through said compression chamber.

12. A fluid pump comprising a cylinder having inlet and discharge ports spaced apart lengthwise therealong, means including a pressure-responsive discharge valve for said discharge port to define a compression chamber at one end of said cylinder, means including a piston rod projecting in lengthwise slideable relation through the other end of said cylinder to define an intake chamber in said cylinder adjacent said inlet port, a sleeve sealingly slideable within a portion of the cylinder that extends between said inlet and discharge ports and loosely surrounding said piston rod to define therewith a fluid passage in said cylinder and extending between said intake and compression chambers, said sleeve and said rod having cooperating sealing surfaces engageable after initial compression movement of said rod to block said fluid passage and to move said sleeve towards said discharge port during further compression movement of said rod and having cooperating abutment surfaces engageable after initial return movement of said rod unblocks said fluid passage to move said sleeve towards said intake port during further return movement of said rod, shiftable means for closing said inlet port, and actuating means for moving said shiftable means and responsive to final compression movement of said rod for moving said shiftable means to port-closing position and responsive to final return movement of said rod for moving said shiftable means away from port-closing position.

13. A fluid pump comprising a cylinder having opposed ends and extending lengthwise between said ends, a discharge port opening into one end of said cylinder, an intake port opening into said cylinder at a point spaced from said discharge port in the lengthwise direction of said cylinder, a pressure-responsive discharge valve normally closing said discharge port, means including a piston rod slideable through the other end of said cylinder to define a compression chamber communicating with said discharge port, an intake chamber communicating with said intake port, and a fluid passage connecting said compression and intake chambers, means responsive to compression movement of said rod to block said passage and to expand said intake chamber and responsive to return movement of said rod to open said passage and to contract said intake chamber, and means including a shiftable member for said intake port for moving said shiftable member to port-closing position at the end of said compression movement and responsive to return movement of said piston rod for moving said shiftable member away from port-closing position at the end of said return movement.

14. A fluid pump comprising a cylinder having opposed ends and extending lengthwise between said ends, a discharge port opening into one end of said cylinder, an intake port opening into said cylinder at a point spaced from said discharge port in the lengthwise direction of said cylinder, a pressure-responsive discharge valve normally closing said discharge port, means including a piston rod slideable through the other end of said cylinder and defining a compression chamber between the end of said piston rod and said one end of said cylinder, an intake chamber communicating with said intake port and having less volumetric displacement than said compression chamber, and a fluid passage connecting said compression and intake chambers, means responsive to compression movement of said rod to block said passage and to expand said intake chamber and responsive to return movement of said rod to open said passage and to contract said intake chamber, and means including a shiftable member for said intake port for moving said shiftable member to port-closing position at the end of said compression movement and responsive to return movement of said piston rod for moving said shiftable member away from port-closing position at the end of said return movement.

15. A fluid pump comprising a casing providing a cylinder having opposed ends and extending lengthwise between said ends, a discharge port opening into one end of said cylinder, an intake port opening into said cylinder at a point spaced from said one end in the lengthwise direction of said cylinder, a pressure responsive discharge valve normally closing said discharge port, means including a piston slidable lengthwise in said cylinder and forming a

compression chamber in said cylinder in communication with said discharge port, an intake chamber in said cylinder in communication with said intake port, a fluid passage in said cylinder and connecting said compression and intake chambers and a valve responsive to compression movement of said piston to block said passage and responsive to return movement of said piston to open said passage, a shiftable member for said intake port, and piston driving means for moving said shiftable member to port closing position at the end of said compression movement and for moving said shiftable member away from port closing position at the end of said return movement.

16. In a fluid pump in combination: means providing a compression chamber having a discharge port, an intake chamber having an intake port and a fluid passage connecting said chambers, movable means operable through a compression stroke for simultaneously contracting said compression chamber and expanding said intake chamber and operable through a return stroke for simultaneously expanding said compression chamber and contracting said intake chamber, valve means operable to block said passage only during said compression stroke, a pressure responsive discharge valve normally closing said discharge port, and means including a shiftable member for said intake port and responsive to said movable means for moving said shiftable member to port closing position at the end of said compression stroke and for moving said shiftable member away from port closing position at the end of said return stroke.

17. In a fluid pump in combination: means providing a compression chamber having a discharge port, an intake chamber of less volumetric displacement than said compression chamber and having an intake port and a fluid passage connecting said chambers, movable means operable through a compression stroke for simultaneously contracting said compression chamber and expanding said intake chamber and operable through a return stroke for simultaneously expanding said compression chamber and contracting said intake chamber, valve means operable to block said passage only during said compression stroke, a pressure responsive discharge valve normally closing said discharge port, and means including a shiftable member for said intake port and responsive to said movable means for moving said shiftable member to port closing position at the end of said compression stroke and for moving said shiftable member away from port closing position at the end of said return stroke.

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