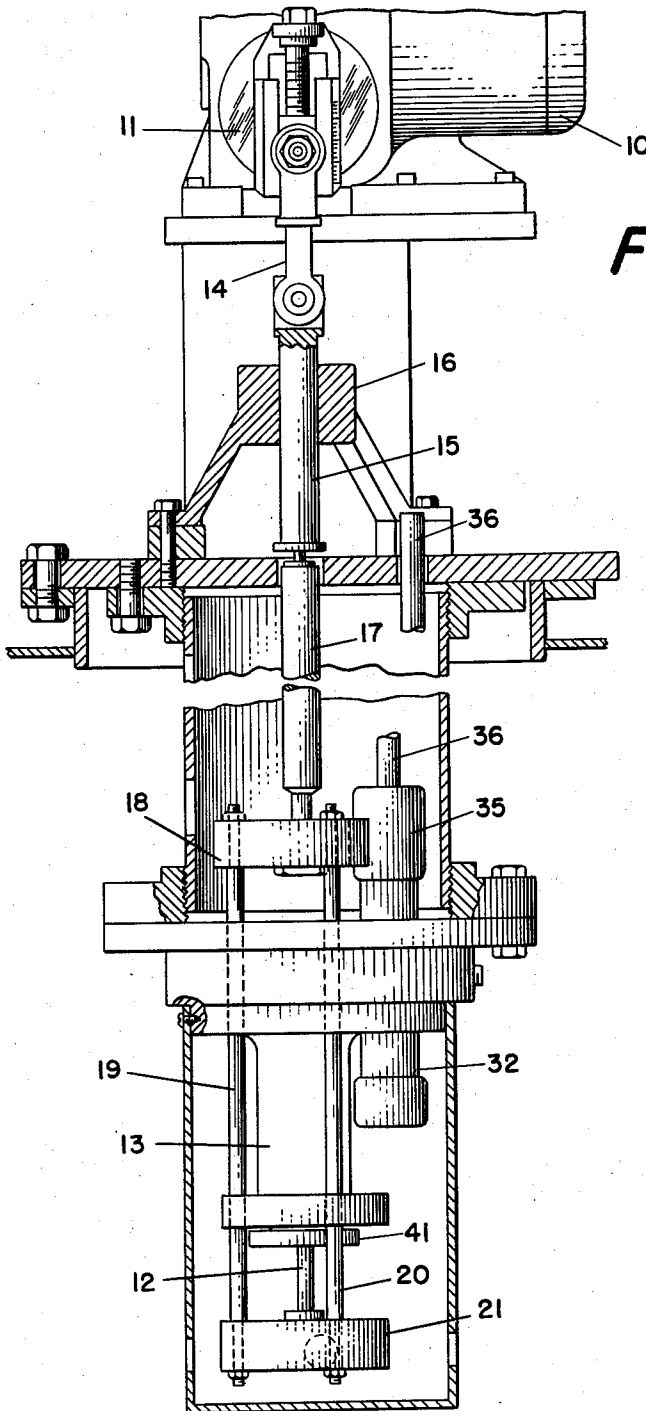


R. A. BENNETT
SELF-ALIGNING PLUNGER DRIVE

2 Sheets-Sheet 1

Fig. 1



July 22, 1958

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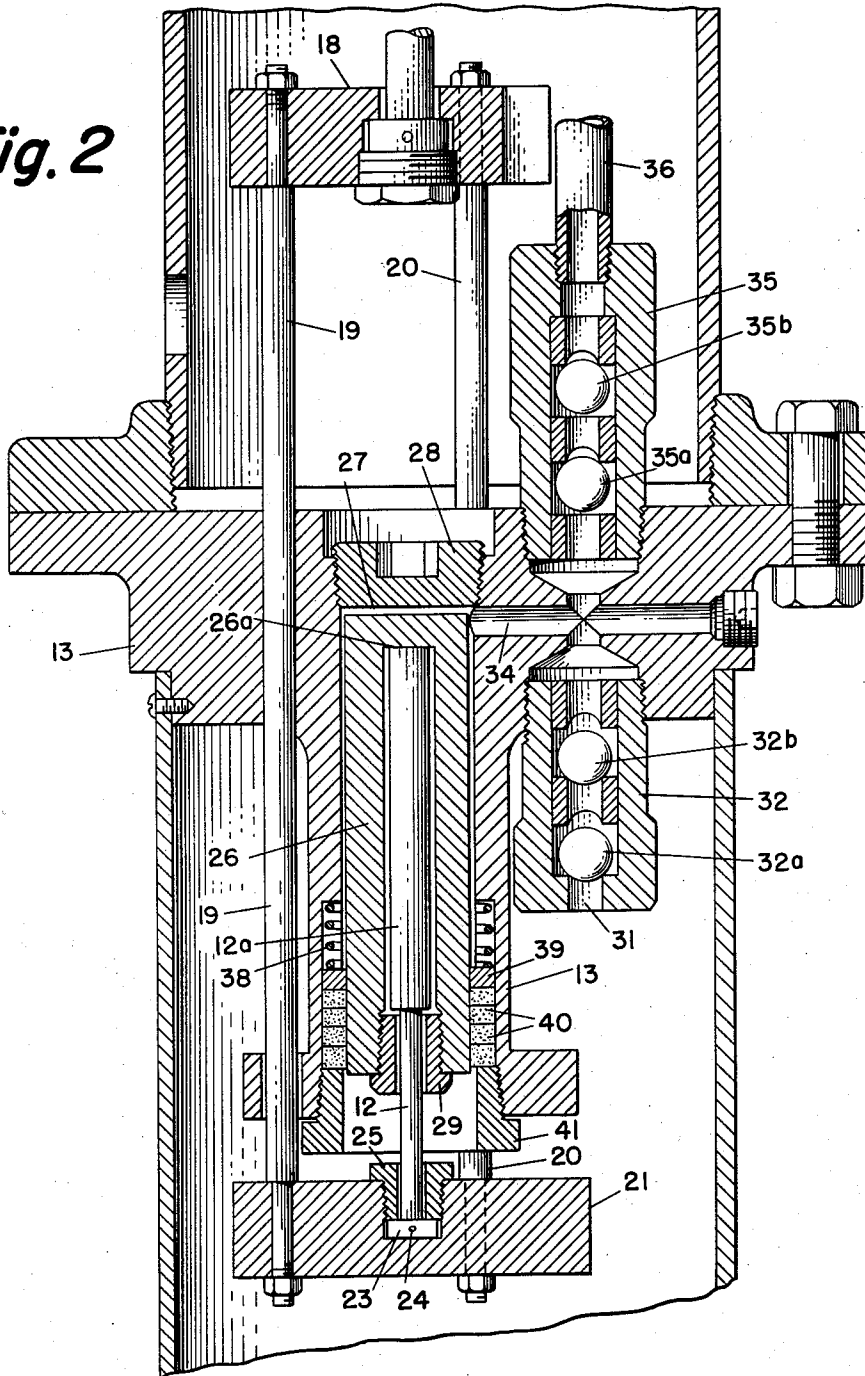
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SELF-ALIGNING PLUNGER DRIVE

Filed Nov. 26, 1954

2 Sheets-Sheet 2

Fig. 2



1

2,844,103

SELF-ALIGNING PLUNGER DRIVE

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4 Claims. (Cl. 103—153)

This invention relates to controlled volume pumps, more particularly to pumps of the submersible type adapted to meter or to produce an accurately controlled flow of liquid from a tank car, a storage tank, or a vat, or from a small vessel.

In the development of a submersible type of pump meeting the requirements of a highly accurate metered flow of a liquid, and as disclosed by copending application Serial No. 465,307, filed October 28, 1954 by Royal Bartlett Saalfrank, a co-employee of mine, something was left to be desired in providing longer trouble-free operation by avoidance of eventual scoring and damage to the packing surrounding the plunger.

A purpose of the invention is to avoid or minimize scoring of packing, or of the plunger or the cylinder when a piston is actuated in a cylinder by reciprocating means such as a push rod which extends generally axially but which may not be truly axial in motion throughout its entire stroke.

A further purpose is effectively to pull the plunger through the cylinder on the pressure stroke by application of the force to the plunger within 25 percent of the distance from the forward end of the plunger to the outside end of the packing so as to minimize thereon a lateral component of the actuating force on the plunger.

A further purpose is to provide a plunger rod extending through the interior of the plunger and having a laterally shiftable connection between the plunger rod and the plunger to compensate for motion of the plunger rod in a direction slightly deviating from the axial direction along the stroke.

In carrying out the present invention in a preferred form thereof, an elongated plunger which is moved into and out of a plunger chamber has the actuating force on the pressure stroke applied thereto at a region in close proximity to its forward end. By reason of this provision, the effect on the plunger as a whole is a self-centering one, analogous and equivalent to an idealized arrangement in which the plunger would be actuated by pulling it from its forward end to produce the pressure or working stroke. A similar action is likewise produced on the return stroke, the point of application of the actuating force shifting with each stroke from the leading to the trailing end of the plunger.

For a more complete understanding of the invention and for further objects and advantages thereof, reference is to be had to the following description taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a side elevation, partly in section, of the pump of said copending application with the present invention applied thereto; and

Fig. 2 is an enlarged sectional elevation of the lower part of Fig. 1.

In many pump applications, especially in deep well pumps and sump pumps, it is desirable to apply the actuating force to a piston in a pump cylinder by reciprocating motion, applied, for example, through a

2

push rod which moves generally axially. This presents problems which are not usually encountered in an ordinary pump installation where the plunger or piston is driven by a connecting rod from a crank or eccentric.

There arises a tendency for the reciprocating element, such as the push rod, to deviate from the truly axial direction at some point along its course of travel. This tendency is particularly pronounced where the structure is elongated, and where, for example, it is possible for shift of relative position to take place even after installation of the equipment, for example, due to deflection of the supporting parts.

While variations from the axial path are objectionable even in pumps which are not intended for precision pumping, this device is particularly objectionable in metering pumps which should deliver precisely measured quantities of liquid within an accuracy of, for example, 1 percent or a few percent. Here deviation from axiality is likely to result in scoring of the packing, the cylinder or the piston or some combination of the same, with the result that changes in the volume relationships and/or leakage may occur, and the pump will cease to deliver accurately.

The present invention is designed to produce highly accurate delivery of liquid to be pumped even in a submersion pump or other structure where the actuation is accomplished by a reciprocating member, and especially where the reciprocating member is elongated and likely to deviate from true axial relationship.

In accordance with the invention, the driving force is applied to a plunger near the front on the pressure stroke so that instead of being pushed, the plunger is in effect pulled. This in itself reduces the tendency to create a lateral component on the plunger due to deflection or deviation from axiality which would cause scoring. In the preferred embodiment, the force is applied to the plunger in the forward 15 percent of the plunger length, measuring from the forward end of the plunger to the outside end of the packing at full stroke. This assures that the greater part of the length of the plunger, and particularly the part that is traveling through the packing, will be in a trailing position with respect to the force application, thus greatly reducing the tendency to score.

The invention furthermore contemplates that there will be lateral freedom between the plunger and the reciprocating force-applying member, generally referred to as a plunger rod, so that instead of distorting the plunger rod where the motion of the push rod is not axial, the relative position of the plunger rod and the plunger can shift slightly laterally without applying any radial or lateral force component of appreciable magnitude on the plunger.

Referring now to the drawings, the invention in one form has been shown as applied to a pump of the submersible type as disclosed in said copending Saalfrank application, and in which a motor 10 through a stroke-adjusting mechanism 11 and an actuating member 12 moves an elongated plunger 26, Fig. 2, within the cylinder or plunger chamber 27 of a combined valve and cylinder block 13. The driving connection from the stroke-adjusting mechanism 11, Fig. 1, is by way of a link 14 and a rod 15 guided in a bracket 16. The rod 15 is connected to a tubular member 17 which has its lower end secured to an upper driving member 18. Preferably three drive rods, two of which, the rods 19 and 20 appear in the drawing, interconnect the upper driving member 18 and a lower driving member 21. The three rods are spaced 120° apart and are guide-supported in openings in the cylinder block 13.

As best shown in Fig. 2, there is a floating driving connection between the cross-head or lower driving member

21 and the plunger-rod or actuating member 12. The driving connection is formed by an enlarged head 23 secured as by a pin 24 to the plunger actuator 12. The enlarged head 23 has freedom of movement in all radial directions in a recess closed by a lock nut 25, the lower end of which forms an upper bearing surface for the enlarged head 23.

The plunger 26 is counterbored to a point adjacent its upper end to receive within the elongated opening the enlarged upper portion 12a of actuator 12. The lower portion of the actuator 12 of smaller cross-sectional area extends loosely through a member 29 which is itself threaded into the lower end of the plunger 26. Thus, as will be seen, the member 29 effectively forms a part of plunger 26 and particularly with respect to its co-operative relationship with the lower surface of the enlarged portion 12a. The distance between the upper face of the member 29 and the upper wall of plunger 26 is slightly greater than the length of the enlarged portion 12a of actuator 12, leaving, with the parts in the position illustrated, a slight axial clearance between the lower face of the enlarged portion 12a and the upper face of the member 29.

With the parts in the position shown, the forward or pressure stroke has just been completed and the upper face of the plunger-actuator 12 is shown bearing against the surface 26a of plunger 26. All portions of plunger 26 below the surface 26a have applied thereto tensional forces and thus the forces tending to move the plunger upwardly are the same as though the plunger were drawn upwardly by pulling from the upper end thereof. By reason of the foregoing arrangement, there is little, if any, tendency of the plunger to be tilted within the cylinder 27.

In this connection, it is to be noted that in a metering or controlled volume type of pump the plunger 26 loosely fits within the plunger chamber or cylinder 27. The metered flow of liquid arises from the volumetric displacement thereof by the plunger 26 and not by reason of a liquid-tight seal between the adjacent surfaces of the plunger and cylinder.

As the return stroke is initiated, there is a slight movement of plunger-actuator 12 downwardly to bring the surface of the shoulder formed by the lower face of the enlarged portion 12a against the upper face of the threaded member 29. Upon engagement of said surfaces, downward movement of plunger 26 is initiated. The downward movement is produced by surfaces located adjacent the lower end of the plunger 26. Thus, on the return stroke the tensional or pulling forces are applied to the lower end of the plunger, minimizing any tendency for it to be tilted or "cocked" within the cylinder 27. As the plunger 26 descends, liquid enters the cylinder by way of an inlet 31 provided in a ball valve assembly 32. The balls 32a and 32b thereof rise to open the passageway for flow of liquid by way of channel 34 into the cylinder which at all times remains full of liquid. Upon completion of the suction or downward stroke of the plunger 26, the ball valves close.

Upon upward movement of plunger 26, the resultant pressure is applied to a valve assembly 35 having balls 35a and 35b which are thereupon moved to their illustrated positions to open the vertically extending passageway into the outlet pipe 36 for outward flow of liquid therethrough. It is to be observed that there is lacking any possibility of air entrapment within the system since the passageway 34 has an entrance into the cylinder adjacent the uppermost part thereof.

Though other packing means may be utilized, I prefer to use a spring 38 disposed with its upper end against a shoulder formed in a counterbore of the cylinder block 13, the spring at its lower end bearing against a metal ring 39 to apply spring pressure against packing elements 40 held in place by a threaded gland member 41.

By reason of the fact that there is a transfer of the

point of application of the actuating force to the plunger 26 first from the driving connection at one end thereof and then to the driving connection at the opposite end thereof upon each reversal of movement, there is avoided or minimized to a negligible degree any tendency of the plunger 26 to be tilted or cocked and to dig into or otherwise score or injure the inner surfaces of the packing elements 40. By providing clearance between the enlarged upper portion 12a of actuating member 12 and the inner bore of the plunger 26, there is always present a self-centering action. The member 12 may bodily move radially or laterally of the plunger 26. The plunger 26 is driven upwardly in coaxial alignment with the actuating member 12 and its enlarged portion 12a. The self-aligning action maintains plunger 26 coaxial of the cylinder or plunger chamber 27. The degree to which the self-centering action is effective has been demonstrated to be sufficient materially to extend the useful life of the packing elements 40 and to provide longer runs between servicing and renewal of such packing elements.

As shown in the drawings, the respective ends of the enlarged portion 12a of the actuating member are located quite close to the ends of the plunger 26. Instead of having the actuating force applied at the lower end of plunger 26, the actuating force on the upward or pressure stroke of plunger 26 is applied at a point near the upper end which is removed from the upper face thereof by only 10 percent to 15 percent of the total length of the plunger 26. While it is preferred that the force of the upper face of actuating member 12 be applied on the working stroke as near the upper face of plunger 26 as possible, improved results will be obtained if the points of engagement are respectively displaced from the upper and lower faces by as much as 25 percent.

By reason of the lateral freedom between the head of the actuating member or plunger rod 12 and the piston, the piston can shift slightly laterally in case the plunger rod head 21 does not move on the axial course. It will be evident that these lateral adjustments may be in the realm of micro inches in some cases, and in the realm of thousandths of an inch in other cases but their effect is substantial as they permit the piston to travel on the compression stroke particularly, and also on the suction stroke, with minimum or no lateral component of movement.

It will be evident that these features are important out of all proportion to the cost of replacing the packing, the piston or the cylinder due to the fact that the location of the pump, due to inaccessibility, hazardous nature of the surrounding area, or the like may not permit inspection, so that if the parts seriously wear or score, the pump may fail to meter accurately and thus cause serious errors in chemical reaction or in the metered flow of liquids whose quantity must be accurately controlled, without the possibility of knowledge by the operator.

It is to be understood the present invention can be applied to other forms of pumps and that I have explained it in connection with the mechanism disclosed in said Saalfrank application in order to show the type of pump in which the invention has proven to be entirely satisfactory.

What is claimed is:

1. In a controlled volume pump, the combination of a cylinder block having an elongated plunger chamber open at one end thereof and closed at a discharge end thereof, inlet and outlet valves in flow communication with said discharge end of said chamber, an elongated hollow plunger closed at one end and open at its opposite end disposed for reciprocation between a position substantially filling said chamber to a position largely withdrawn from said chamber, stationary packing means for said plunger forming a liquid seal between said plunger and that portion of said chamber adjacent said open end, driving means

5

for reciprocating said plunger free from development of radial forces of substantial magnitude comprising an elongated actuating element disposed within said hollow plunger, said plunger and said actuating element each having driving surfaces located at opposite end portions of said elongated plunger, the distance between said surfaces on said actuating element being less than between said surfaces on said plunger for alternate engagement of said surfaces at said opposite end portions of said plunger, said actuating element extending outwardly of said hollow plunger through the open end thereof and having radial clearance therewith for relative radial movement between said plunger and said element, and reciprocating means connected to said outwardly extending actuating element for moving said element to engage said driving surfaces located adjacent the closed end of said plunger for moving said plunger into said chamber and for moving said element to disengage said last-named surfaces and to engage said driving surfaces adjacent said open end of said plunger for moving said plunger outwardly of said plunger chamber.

2. In a controlled volume pump, the combination of a cylinder block having an elongated plunger chamber open at one end thereof and closed at a discharge end thereof, inlet and outlet valves in flow communication with said discharge end of said chamber, an elongated hollow plunger closed at one end and open at its opposite end disposed for reciprocation between a position substantially filling said chamber to a position largely withdrawn from said chamber, stationary packing means adjacent the open end of said plunger chamber forming a liquid seal between said plunger and the wall of said chamber, driving means for moving said plunger axially of said plunger chamber free from development of radial forces of substantial magnitude comprising an elongated actuating element disposed within said hollow plunger, said plunger and said actuating element each having driving surfaces located at opposite end portions of said plunger, the distance between said surfaces on said element being less than between said surfaces on said plunger for alternate engagement of said surfaces at said opposite end portions of said plunger, said actuating element extending outwardly of said hollow plunger through the open end thereof and having radial clearance therewith for self-centering relative radial movement between said plunger and said element, and reciprocating means including a member connected to said outwardly extending actuating element and extending outwardly beyond the cylinder block of said chamber, and rod means connected to said member and extending in spaced relation with said cylinder block in the region of said plunger chamber to a position in spaced relation with said valves for moving said element to engage said driving surfaces located adjacent the closed end of said plunger for moving said plunger into said chamber and for moving said element to disengage said last-named surfaces and to engage said driving surfaces adjacent said open end of said plunger for moving said plunger outwardly of said plunger chamber.

3. In a controlled volume pump of the submersible type, the combination of a cylinder block having an elongated plunger chamber open at the lower end thereof and closed at its upper discharge end thereof, inlet and outlet valves in flow communication with said discharge end of said chamber, an elongated hollow plunger closed at one

6

end and open at its opposite end disposed for reciprocation between a position substantially filling said chamber to a position largely withdrawn from said chamber, packing means for said plunger forming a liquid seal between said plunger and said open end of said chamber, driving means for reciprocating said plunger free from development of radial forces of substantial magnitude comprising an elongated actuating element disposed within said hollow plunger, said plunger and said actuating element each having driving surfaces located at opposite end portions of said plunger, the distance between said surfaces on said element being less than between said surfaces on said plunger for alternate engagement of said surfaces at said opposite end portions of said plunger, said actuating element extending downwardly from and outwardly of said hollow plunger through the open end thereof and having radial clearance therewith for relative radial movement between said plunger and said element, a lower driving member, an upper driving member, rod means rigidly interconnecting said members, a mechanical connection between said lower driving member and the lower end of said actuating element having radial clearance for relative radial movement between said lower member and said element, reciprocating drive means disposed above said plunger chamber having a drive rod extending downwardly therefrom, and a mechanical connection between said upper driving member and said drive rod having radial clearance for relative radial movement between them for moving said element to engage said driving surfaces located adjacent the closed end of said plunger for moving said plunger into said chamber and for moving said element to disengage said last-named surfaces and to engage said driving surfaces adjacent said open end of said plunger for moving said plunger outwardly of said plunger chamber.

4. In a controlled volume pump including a plunger chamber, inlet and outlet valve means connected to the interior of the plunger chamber, an elongated plunger movable into and outwardly of the plunger chamber, and reciprocating means moving longitudinally and axially of the plunger chamber for reciprocating the plunger, the improvement which comprises an elongated driving element connected to the reciprocating means extending into and surrounded by the plunger, and laterally shiftable driving connections between said plunger and said driving element respectively located adjacent opposite end portions of said elongated plunger and selectively effective to move said plunger, relative axial movement of said driving element relative to said plunger upon reciprocation of said driving element rendering effective first one and then the other of said driving connections for movement of said plunger by the driving connection adjacent the end portion of said plunger which forms the leading end thereof during its movement into and out of said plunger chamber.

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