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Sommer

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[54] **PUMP SPRAY UNIT**

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[52] **U.S. Cl.** **417/214,** 417/387
[51] **Int. Cl.** **F04b 49/00**
[58] **Field of Search** 417/383, 385–388, 417/214

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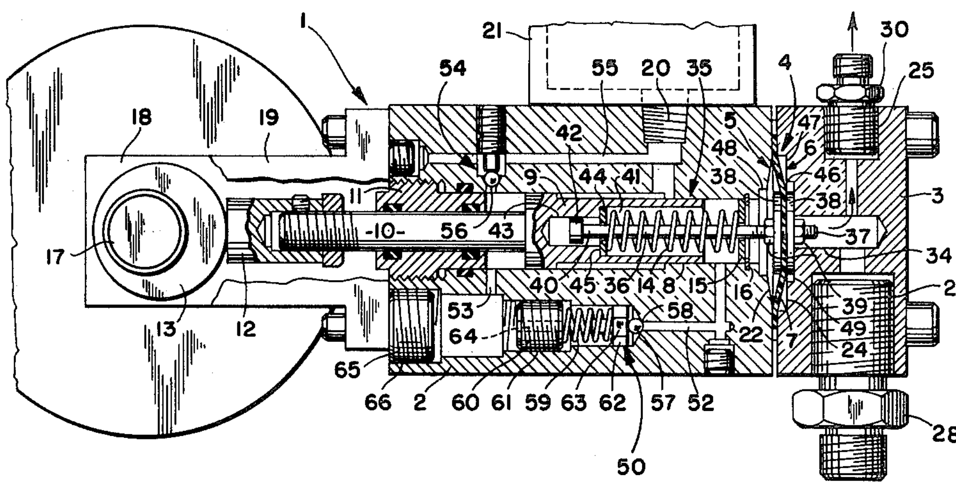
[57] **ABSTRACT**

Pump spray unit has a lost-motion connection between the pump diaphragm and pump piston which ensures full retraction of the diaphragm during retraction of the piston for obtaining the desired amount of working fluid within the working fluid chamber prior to the pumping stroke of the piston and diaphragm. An adjustable relief valve is also provided for relieving the excess working fluid pressure which is created during standby operation of the pump to the back side of the piston which causes the piston to move forward out of engagement with its drive cam thereby retaining the piston and diaphragm against movement during standby to minimize wear and power consumption during standby. The high pressure acting on the back side of the piston is bled off through a restricted orifice, and when pumping is resumed the pressure quickly drops to a level at which the piston is again urged by a return spring into engagement with the drive can for reciprocation thereby.

14 Claims, 5 Drawing Figures



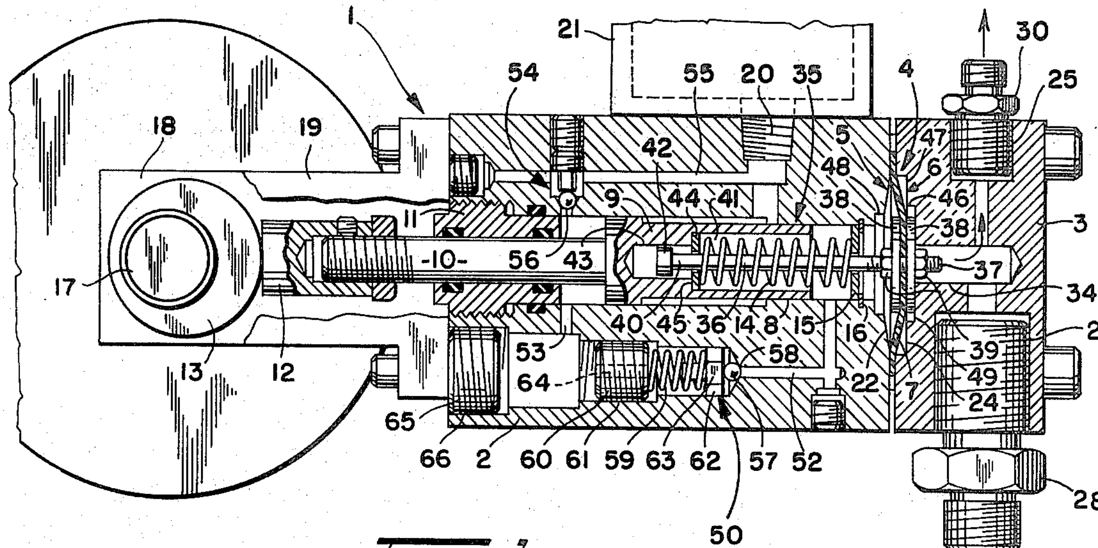

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Fig. 1

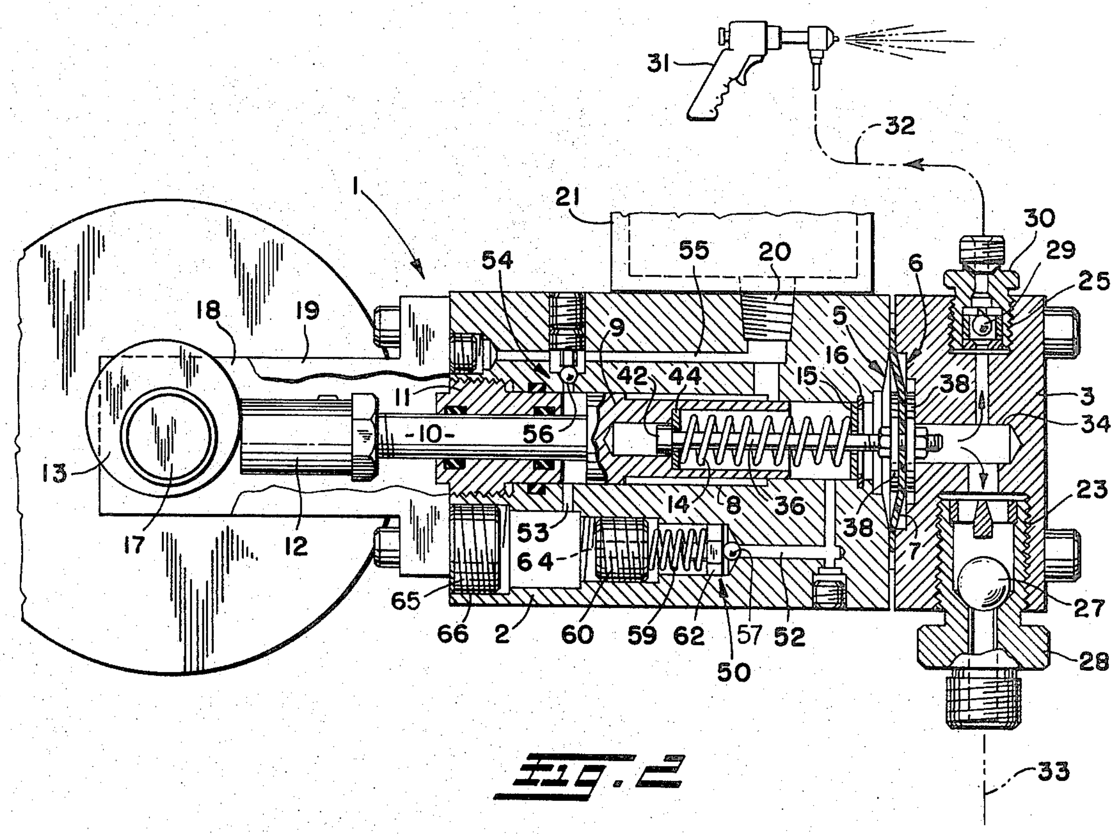
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Fig. 2

FIG. 3

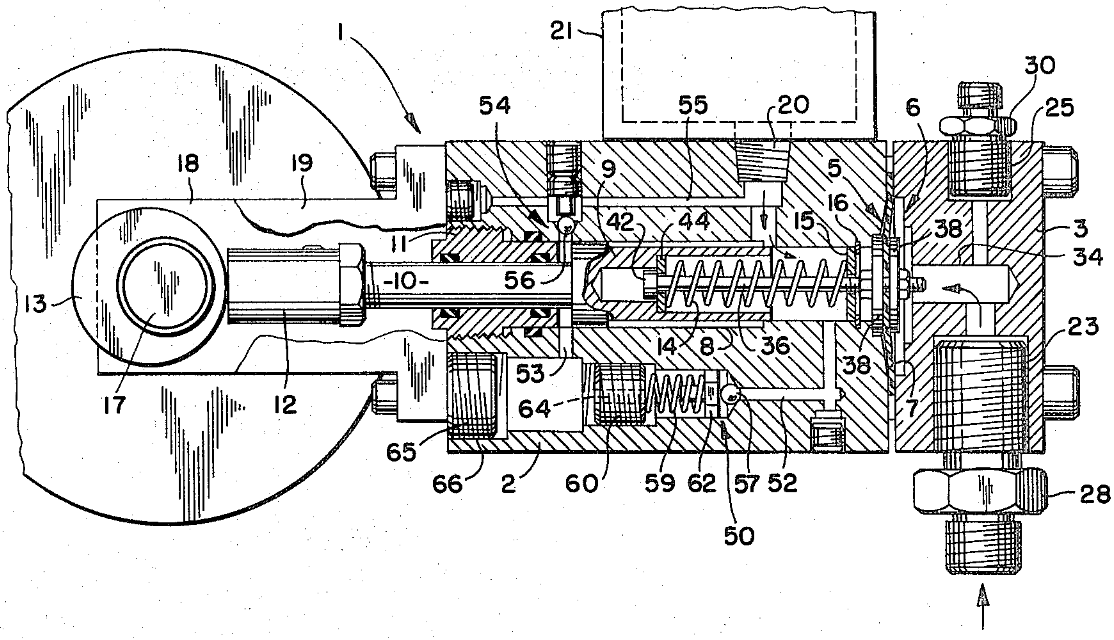
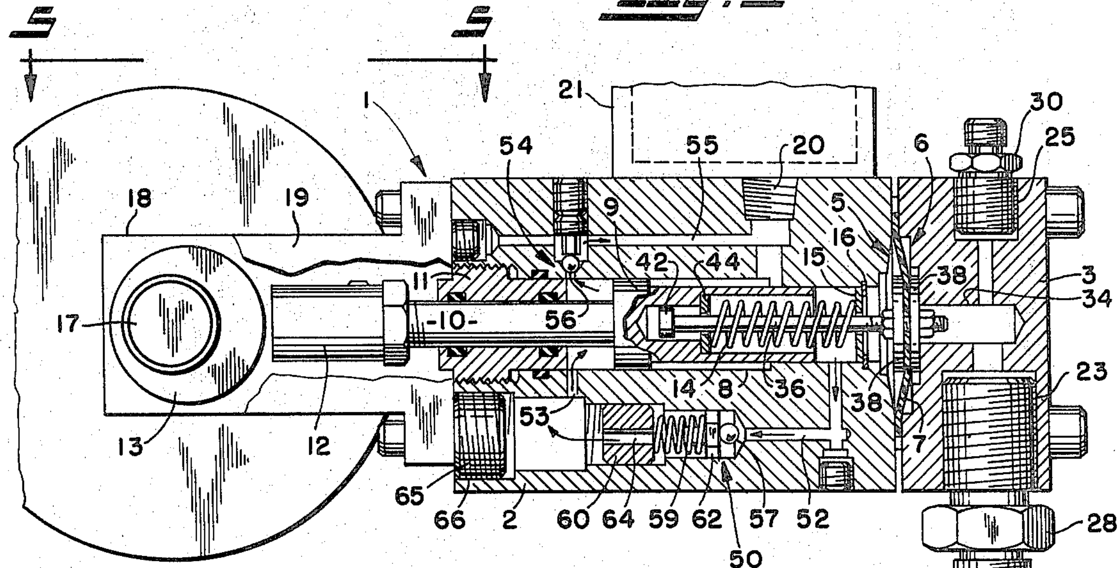


FIG. 4



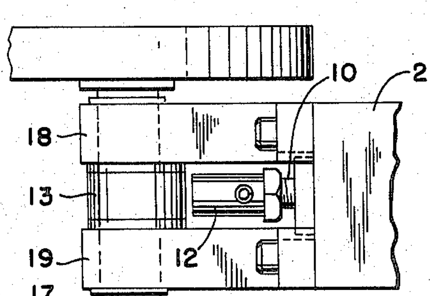


FIG. 5

PUMP SPRAY UNIT

BACKGROUND OF THE INVENTION

This invention relates generally as indicated to a pump spray unit, and more particularly, to certain improvements in pump spray units for increasing the life and efficiency thereof.

In general, the pump spray unit of the present invention is of the type including a diaphragm which is caused to be flexed back and forth by reciprocation of a piston to create the desired pumping force. The piston acts on a working fluid such as oil which creates a partial vacuum during the intake stroke of the piston. This normally causes the diaphragm to flex in a direction to draw the fluid to be pumped such as paint into a pumping chamber, and such fluid is subsequently expelled from the pumping chamber under pressure during the discharge stroke of the piston.

There are occasions when, however, the partial vacuum which is created during the intake stroke of the piston does not flex the diaphragm at all or at least not to the desired extent due to paint adhering the diaphragm to the wall of the pumping fluid chamber, lack of sufficient vacuum, and so on. The net result is that more oil enters the pumping chamber during the return stroke of the piston than is required to flex the diaphragm in the pumping direction during the pumping stroke, whereby the diaphragm is subjected to increased pressure which overly tightly presses the diaphragm against the wall of the pumping chamber and may extrude the diaphragm into the pumping chamber.

A conventional return spring is sometimes applied to the diaphragm to make certain of its return movement during retraction of the piston, but such a return spring places a constant load on the diaphragm and requires increased pressure to be applied to the diaphragm during the pumping stroke of the piston to overcome the force of the spring as well as provide sufficient pressure to pump the fluid from the pumping chamber.

Another disadvantage of most diaphragm pumps is that as long as the drive motor is operating, the piston and diaphragm are continually reciprocated even during standby operation of the pump when the flow output from the pump is interrupted by the operator. This results in increased wear on the pump parts, and considerable power is also consumed during standby even though no fluid is actually being discharged from the pump.

SUMMARY OF THE INVENTION

With the foregoing in mind, it is a principal object of this invention to provide a pump spray unit in which full return movement of the diaphragm is insured during retraction of the piston without placing any undue stresses on the diaphragm.

Another object is to provide such a pump spray unit in which the diaphragm is always controlled in its movement and the oil volume is maintained at the desired level so as not to extrude the diaphragm into the pumping chamber during the pumping stroke.

Still another object is to provide such a pump spray unit in which the fluid discharged through the relief valve on standby will cause the piston to disengage sufficiently for a predetermined number of strokes to minimize temperature rise.

Yet another object is to provide such a pump spray unit in which both the piston and diaphragm of the pump remain stationary during standby operation of the pump for increased life and efficiency.

These and other objects of the present invention may be obtained by providing a lost-motion connection between the diaphragm and drive piston to insure full return movement of the diaphragm during retraction of the piston. The lost-motion connection desirably consists of a rod having one end connected to the diaphragm and the other end received in a central recess in the piston, with an enlarged head on such other end which is engaged by a stop plate in the central recess to mechanically pull the diaphragm to its full return position in the event that the partial vacuum created by the piston during retraction thereof is not effective in doing so. Because the diaphragm is always flexed to its full return position during retraction of the piston, the working fluid which enters the pumping chamber at that time is maintained at a desired level sufficient to flex the diaphragm to the desired extent during the pumping stroke of the piston without subjecting the diaphragm to any undue pressure or causing the diaphragm to be extruded into the pumping chamber.

An adjustable relief valve is also provided for relieving the excess oil pressure which develops during standby operation of the pump. The excess oil pressure is desirably directed to the back side of the piston, whereby the high fluid pressure acting on the back side of the piston causes the piston to move forward out of contact with its drive cam with the result that the piston and diaphragm will remain almost stationary for a predetermined number of strokes during standby operation of the pump for increased pump life and efficiency. A restricted orifice is provided for bleeding off the high pressure acting on the back side of the piston, whereby when pumping is resumed, the pressure quickly drops to a level at which a spring acting on the front side of the piston will move the piston once again back into engagement with the drive cam for reciprocation thereby.

To the accomplishment of the foregoing and related ends, the invention, then, comprises the features hereinafter fully described and particularly pointed out in the claims, the following description and the annexed drawings setting forth in detail a certain illustrative embodiment of the invention, this being indicative, however, of but one of the various ways in which the principles of the invention may be employed.

BRIEF DESCRIPTION OF THE DRAWINGS

In the annexed drawings:

FIG. 1 is a fragmentary longitudinal section through a preferred form of pump spray unit constructed in accordance with the present invention showing the piston and diaphragm in the full extended position;

FIG. 2 is a fragmentary longitudinal section similar to FIG. 1 showing the diaphragm still in the fully extended position but with the piston partially retracted;

FIG. 3 is a fragmentary longitudinal section similar to FIG. 2, but showing both the piston and diaphragm in the fully retracted position;

FIG. 4 is a fragmentary longitudinal section similar to FIG. 1 but showing the piston extended further forward out of contact with the drive cam so that both the piston and diaphragm will remain stationary during standby operation of the pump; and

FIG. 5 is a fragmentary top plan view of the drive mechanism at the left end of the pump spray unit of FIG. 4 as seen from the plane of the line 5—5 thereof.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now in detail to the drawings and initially to FIG. **1** thereof, there is shown a preferred form of pump spray unit **1** in accordance with this invention including a main housing **2** to one end of which is bolted another housing **3** defining therebetween a cavity **4** which is divided into two separate chambers **5** and **6** by a flexible diaphragm **7** clamped between the two housings around the outer periphery of the diaphragm.

A longitudinal bore **8** extends through the main housing **2** and communicates with the chamber **5**. Contained within the longitudinal bore **8** is a piston **9** having a rod **10** extending outwardly therefrom through a suitable packing **11** threadedly received in the outer end of the bore. Threadedly attached to the outer end of the rod **10** is a cam follower **12** which is normally maintained in engagement with an eccentric drive cam **13** by a spring **14** interposed between the inner end of the piston **9** and a washer **15** retained in position within the inner end of the bore **8** as by a snap ring **16** or the like. The eccentric drive cam **13** is driven by a crank shaft **17** which may be suitably journalled within a pair of laterally spaced end plates **18, 19** bolted or otherwise secured to the other end of the main housing **2** as best seen in FIG. **5**. As apparent, rotation of the crank shaft **17** and eccentric drive cam **13** mounted thereon as by means of a drive motor (not shown) suitably connected thereto will cause the piston **9** to reciprocate within the bore.

The bore **8** forwardly of the piston **9** and chamber **5** are maintained filled with a suitable working fluid such as oil by providing a passage **20** in the main housing **2** which communicates the bore with an oil reservoir **21** when the piston is retracted as shown in FIG. **3**. During such retraction of the piston **9** from the FIG. **1** position to the FIG. **3** position, a partial vacuum is created in the forward end of the bore **8** and working fluid chamber **5** which normally causes the diaphragm **7** to flex toward the working fluid chamber wall **22**. Such flexing of the diaphragm **7** in turn creates a partial vacuum in the pumping fluid chamber **6**, causing paint or other fluid to be pumped to be drawn into the pumping fluid chamber **6** through an inlet opening **23** in the housing **3**. On the discharge stroke of the piston **9**, the diaphragm is flexed in the reverse direction toward the pumping fluid chamber wall **24**, which creates a pressure on the pumping fluid forcing the pumping fluid from the pumping chamber **6** under pressure through an outlet opening **25** in the housing. As can be seen in FIG. **2**, an inlet valve **27** contained within an inlet valve body **28** threadedly received in the inlet opening **23** is forced closed by the fluid pressure within the pumping chamber **6** during the pumping stroke, and an outlet valve **29** contained within a valve body **30** threadedly received in the outlet opening **25** is opened by such fluid pressure for discharge of the pumping fluid through the outlet opening which may be connected to a spray nozzle **31** or other such device as by means of a hose **32** schematically illustrated in FIG. **2**. A hose **33** also schematically shown in FIG. **2** may be connected to the inlet valve body **28** and inserted into a suitable container for the fluid to be pumped such as a 5-gallon paint drum.

The partial vacuum which is created during retraction of the piston **9** is normally sufficient to cause the diaphragm **7** to flex to its fully retracted position shown in FIG. **3**. However, there are occasions when the diaphragm may stick in the fully extended position or only move partially toward the retracted position, in which event a greater amount of working fluid will enter the bore when the piston is fully retracted than is required to move the diaphragm back to its fully extended position during the pumping stroke of the piston. This results in increased fluid pressure acting on the diaphragm **7** pressing the diaphragm more tightly against the wall **24** of the pumping fluid chamber **6** and tending to extrude the diaphragm into the central opening **34** in the housing **3** communicating with the inlet and outlet passages **23** and **25** therein.

In order to prevent such undue pressure from being applied to the diaphragm **7**, a lost-motion connection **35** is provided between the diaphragm and the piston which insures full retraction of the diaphragm when the piston reaches the end of its stroke. As shown, such lost-motion connection **35** desirably consists of a rod **36** having one end **37** connected to the diaphragm centrally thereof by a pair of washers **38**, one disposed on each side of the diaphragm with the end **37** of the rod extending through aligned openings in the washers and diaphragm, and a pair of nuts **39** threaded on the rod on opposite sides of the washers which are tightened for clamping the diaphragm between the washers. The other end **40** of the rod **36** extends into a stepped central recess **41** within the piston **9** and has a head **42** thereon which is received in the innermost smaller diameter portion **43** of the central recess **41**. Also contained within the central recess **41** is a stop plate or washer **44** which is held against a step or shoulder **45** in the central recess by the return spring **14** for the piston.

As evident from FIGS. **1** and **2**, during the initial movement of the piston **9** from the fully extended position shown in FIG. **1** to the fully retracted position, the piston is free to move relative to the rod **36** and diaphragm **7** connected thereto. However, if during such retraction of the piston the partial vacuum which is created is not sufficient to cause the desired flexing movement of the diaphragm to its fully retracted position, the stop plate or washer **44** within the central recess **41** in the piston will engage the head **42** on the rod as shown in FIG. **2** and cause the rod and diaphragm to move rearwardly with the piston during the remainder of its stroke from the FIG. **2** position to the FIG. **3** position. Accordingly, movement of the diaphragm to its retracted position during retraction of the piston is always assured, whereby the amount of working fluid within the bore will always remain the same and be sufficient to move the diaphragm back to its fully extended position during the pumping stroke of the piston without placing undue pressure on the diaphragm or causing the diaphragm to be extruded against the wall of the pumping chamber **6**.

Providing a direct connection between the return spring **14** and diaphragm **7** rather than a lost-motion connection **35** through the piston **9** as previously described will also assure complete retraction of the diaphragm during retraction of the piston. However, in that event the spring **14** pressure will place undesirable stresses on the diaphragm and require additional fluid pressure to be exerted on the diaphragm during the pumping stroke to flex the diaphragm to the fully extended position.

Another advantage in providing such a lost-motion connection 35 between the diaphragm 7 and piston 9 as previously described is that if for one reason or another the diaphragm is locked against movement in its fully extended position, the return spring **14** will permit continued retraction of the piston from the FIG. **2** position to the FIG. 3 position even if the diaphragm is not free to move.

Damage to the diaphragm 7 by engagement with the walls **22** and **24** of the chambers **5** and **6** during flexing of the diaphragm may also be minimized by making the working fluid chamber wall **22** generally spherical in shape to conform to the natural form or shape taken by the diaphragm when flexed and also by substantially relieving the wall **24** of the pumping fluid chamber **6** to avoid direct contact of the diaphragm with the edge **46** of the relieved portion **47**. The walls **16** and **24** of the chambers **5** and **6** may also be further relieved centrally thereof as shown to provide annular recesses **48** and **49** for receipt of the clamping washers **38**.

As long as the spray nozzle **31** is open, the pump spray unit **1** will continue to discharge pumping fluid at a relatively constant pressure. However, when the spraying operation is interrupted, the pressure within the pump will continue to build up until relieved by a pressure relief valve **50** contained in a passage **52** in the main housing **2** communicating with the longitudinal bore **8** forwardly of the piston **9**. In the usual pump construction, such a relif valve is used to dump the excess working fluid acted on by the piston directly back to the oil reservoir thus to prevent an excess build up of pressure within the pump during standby operation. However, ordinarily as long as the motor which drives the crank shaft **17** is operating, the piston **9** will continue to reciprocate back and forth causing the diaphragm **7** to flex no matter how long the pump may be on standby, resulting in needless wear of the various pump parts and power consumption during stand-by operation.

With the pump construction of the present invention, however, such needless wear and power consumption during standby operation is eliminated by providing suitable passages **53** in the main housing **3** for directing the excess working fluid relieved by the pressure relief valve **50** to the outer end of the longitudinal bore **8** where it acts on the back side of the piston **9**. By making the back side of the piston **9** of a larger area than the front side thereof, the excess working fluid pressure acting on the back side of the piston will cause the piston to move forward out of contact with the drive cam **13** as shown in FIG. **4**. The piston **9** will remain out of contact with the drive cam **13** as long as the force of the pressure acting on the rear side of the piston is greater than the combined force of the pressure and spring **14** acting on the front side of the piston, which will normally be the case during standby operation, whereby both the piston **9** and diaphragm **7** will remain stationary during standby operation to minimize wear on the parts and reduce power consumption.

As soon as pumping is resumed, the pressure relief valve **50** will close and the high pressure acting on the rear side of the piston **9** will be bled off through a restricted orifice **54** which provides communication between the outer end of the longitudinal bore **8** and the reservoir **21** through an additional passage **55** in the main housing **3**. When the force of the pressure acting on the rear side of the piston **9** drops below the combined force of the pressure and spring **14** acting on the front side of the piston, the piston will once again be moved back into engagement with the drive cam **13** at which time normal pumping will be resumed.

The size of the restricted orifice **54** may be varied as by providing an adjustable check valve **56** in the passage which also prevents flow of working fluid from the reservoir **21** to the outer end of the longitudinal bore. There may be slight cavitation in the outer end of the longitudinal bore adjacent the rear side of the piston during reciprocation of the piston, but not enough to adversely affect the operation of the pump.

The pressure relief valve **50** may also be made adjustable for varying the pressure level at which the pressure relief valve will open, and such pressure relief valve desirably consists of a ball valve **57** normally urged into engagement with a seat **58** by a spring **59** interposed between an adjusting screw **60** threadedly received in a recess **61** in the main housing **3** and a pressure plate **62** engaging the ball valve. The pressure plate **62** may have flats **63** thereon permitting fluid to bypass the pressure plate, and the adjusting screw **60** may have a longitudinal opening **64** therethrough for passage of such fluid. Adjustment of the spring **59** pressure acting on the pressure plate **62** may be varied by rotating the adjusting screw **60** which is accessible by removing a plug **65** threadedly received in an access opening **66** in the main housing.

From the foregoing, it will now be apparent that the pump spray unit of the present invention provides for controlled movements of the diaphragm and insures that the working fluid pressure is maintained at the desired level during pumping so as not to cause damage to the diaphragm or extrude the diaphragm into any openings and the like. The piston and diaphragm also remain stationary during standby operation of the pump, which results in a savings of power and also minimizes wear of parts during standby.

I claim:

1. A pump comprising a housing, a cavity within said housing, a flexible diaphragm dividing said cavity into two separate chambers, a bore communicating with one of said chambers, a piston contained within said bore, drive means for reciprocating said piston within said bore to force a working fluid into and out of said one chamber for flexing said diaphragm in opposite directions thereby respectively decreasing and increasing the volume of the other of said chambers for pumping fluid into and out of said other chamber, and means providing a lost-motion connection between said piston and diaphragm to insure flexing of said diaphragm in a direction causing a reduction in the size of said one chamber during retraction of said piston, said means providing a lost-motion connection between said piston and diaphragm comprising a rod having one end connected to said diaphragm, a stepped recess in said piston into which the other end of said rod extends, said other end of said rod having a head thereon extending inwardly beyond the step in said recess, and a washer engaging said step for contacting said head during retraction of said piston to mechanically retract said diaphragm with said piston in the event that the partial vacuum which is created during retraction of said piston is not effective in causing said diaphragm to flex as aforesaid.

2. The pump of claim **1** further comprising a spring urging said washer into engagement with said step.

3. The pump of claim 2 wherein said spring is contained within said bore interposed between said washer and another washer in said bore.

4. The pump of claim 1 wherein the connection between said one end of said rod and said diaphragm consists of a pair of washers on opposite sides of said diaphragm, said one end of said rod extending through aligned openings in said washers and diaphragm, and a pair of nuts threadedly engaging said rod on opposite sides of said washers which are tightened for clamping said diaphragm between said washers.

5. The pump of claim 4 wherein the wall of said other chamber is relieved to avoid contact by said diaphragm during flexing of said diaphragm in the pumping direction.

6. A pump comprising a housing, a cavity within said housing, a flexible diaphragm dividing said cavity into two separate chambers, a bore communicating with one of said chambers, a piston contained within said bore, drive means for reciprocating said piston within said bore which forces a working fluid into and out of said one chamber for flexing said diaphragm in opposite directions thereby respectively decreasing and increasing the volume of the other of said chambers for pumping fluid into and out of said other chamber, and means for disconnecting said piston from said drive means when the pressure within said one chamber reaches a predetermined high level during standby operation of said pump to cause said piston and diaphragm to remain stationary during such standby operation, said drive means comprising a drive cam, said piston having a rod projecting from the outer end thereof, and a spring engaging the inner end of said piston for urging said rod into engagement with said drive cam during normal operation of said pump.

7. The pump of claim 6 wherein said means for disconnecting said piston from said drive means comprises passage means providing communication between opposite ends of said bore on opposite sides of said piston, and pressure relief valve means contained within said passage means which is opened in response to the pump pressure reaching such predetermined high level to prevent increased pressure build up within said pump, such high fluid pressure which is relieved by said pressure relief valve means being directed to the outer end of said bore by said passage means whereat such high fluid pressure acts on the back side of said piston which has an effective area sufficiently larger than the effective area of the front side of said piston that when such predetermined high pressure is reached, said rod is moved out of engagement with said drive cam thereby causing said piston and diaphragm to remain stationary during continued rotation of said drive cam.

8. The pump of claim 7 further comprising a restricted orifice for bleeding off the high pressure acting on the back side of said piston when normal pumping is resumed.

9. The pump of claim 8 wherein said restricted orifice comprises an adjustable check valve disposed in a further passage communicating said outer end of said bore with a reservoir containing such working fluid.

10. The pump of claim 7 wherein said pressure relief valve means comprises a ball valve contained in said passage providing communication between opposite ends of said bore, a seat in said passage for said ball valve, and spring means urging said ball valve into engagement with said seat, and an adjusting screw threadedly received in said passage for varying the pressure of said spring means acting on said ball valve, said adjusting screw having a central passage therethrough for such high pressure fluid.

11. The pump of claim 10 further comprising a pressure plate in said passage interposed between said spring means and ball valve, said pressure plate having flats thereon permitting fluid to bypass said pressure plate.

12. A pump comprising a housing, a cavity within said housing, a flexible diaphragm dividing said cavity into two separate chambers, a bore communicating with one of said chambers, a piston contained within said bore, drive means for reciprocating said piston within said bore to force a working fluid into and out of said one chamber for flexing said diaphragm in opposite directions thereby respectively decreasing and increasing the volume of the other of said chambers for pumping fluid into and out of said other chamber, means providing a lost-motion connection between said piston and diaphragm to insure flexing of said diaphragm in a direction causing a reduction in the size of said one chamber during retraction of said piston, and means for disconnecting said piston from said drive means when the pressure within said one chamber reaches a predetermined high level during standby operation of said pump to cause said piston and diaphragm to remain stationary during such standby operation of said pump.

13. pump comprising a housing, a cavity within said housing, a flexible diaphragm dividing said cavity into two separate chambers, a bore communicating with one of said chambers, a piston contained within said bore, drive means for reciprocating said piston within said bore which forces a working fluid into and out of said one chamber for flexing said diaphragm in opposite directions thereby respectively decreasing and increasing the volume of the other of said chambers for pumping fluid into and out of said other chamber, and means for disconnecting said piston from said drive means in response to the pressure within said one chamber reaching a predetermined high level during standby operation of said pump to cause said piston and diaphragm to remain stationary during such standby operation while said drive means continues to operate.

14. A pump comprising a housing, a cavity within said housing, a flexible diaphragm dividing said cavity into two separate chambers, a bore communicating with one of said chambers, a piston contained within said bore, drive means for reciprocating said piston within said bore to force a working fluid into and out of said one chamber for flexing said diaphragm in opposite directions thereby respectively decreasing and increasing the volume of the other of said chambers for pumping fluid into and out of said other chamber, and means providing a lost-motion connection between said piston and diaphragm to insure flexing of said diaphragm in a direction causing a reduction in the size of said one chamber during retraction of said piston, said lost-motion connection including means permitting freedom of movement of said piston relative to said diaphragm during the initial movement of said piston from the fully extended position toward the fully retracted position, and means for positively retracting said diaphragm with said piston as said piston approaches the fully retracted position to assure such flexing of said diaphragm in the event said diaphragm does not flex in the desired direction as aforesaid during the initial movement of said piston toward the fully retracted position.

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