VARIABLE-CAPACITY METERING PUMP

Original Filed May 17, 1954 4 Sheets-Sheet 1

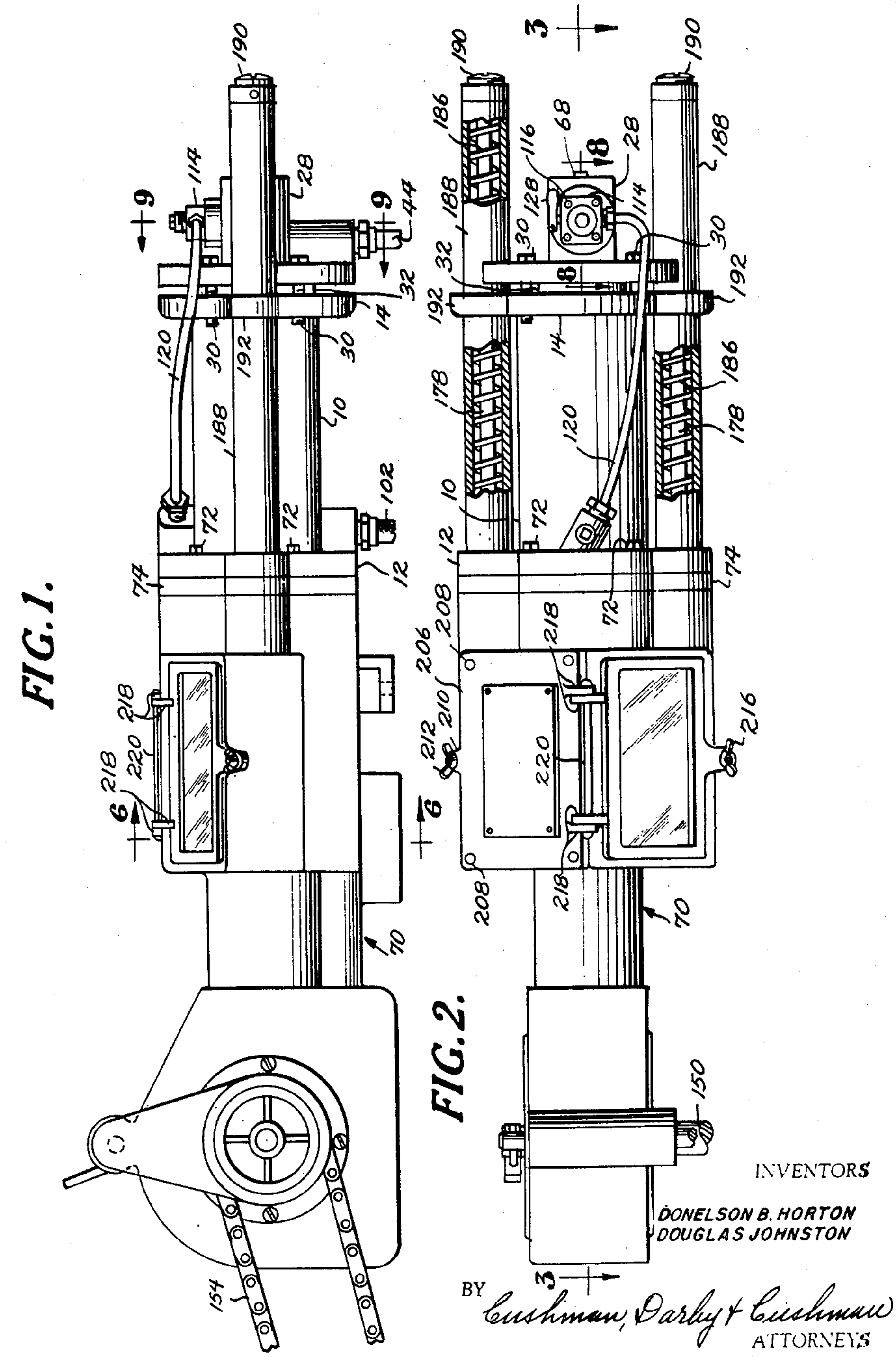


FIG. 1. FIG. 2.

INVENTORS
DONELSON B. HORTON
DOUGLAS JOHNSTON
BY Cushman, Darby & Cushman
ATTORNEYS

Oct. 29, 1957 D. B. HORTON ET AL 2,811,108

VARIABLE-CAPACITY METERING PUMP

Original Filed May 17, 1954 4 Sheets-Sheet 2

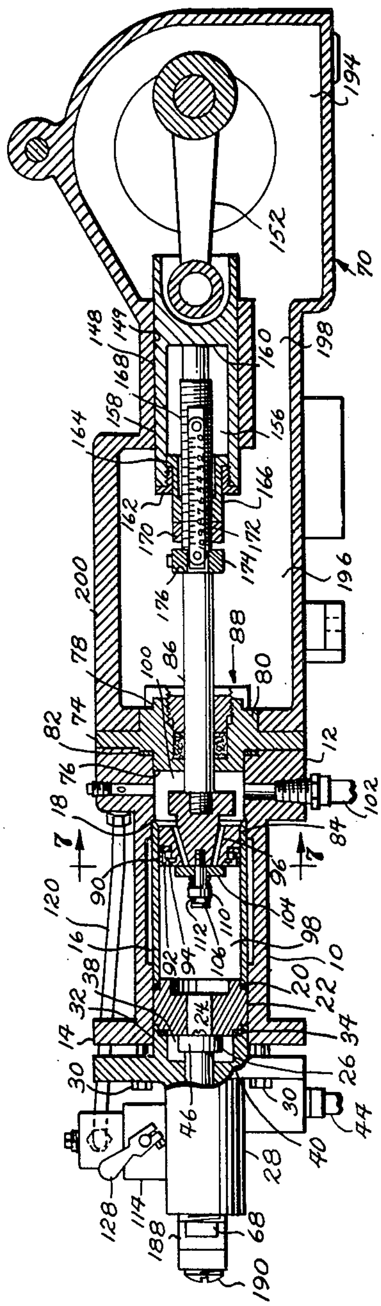


FIG. 3.

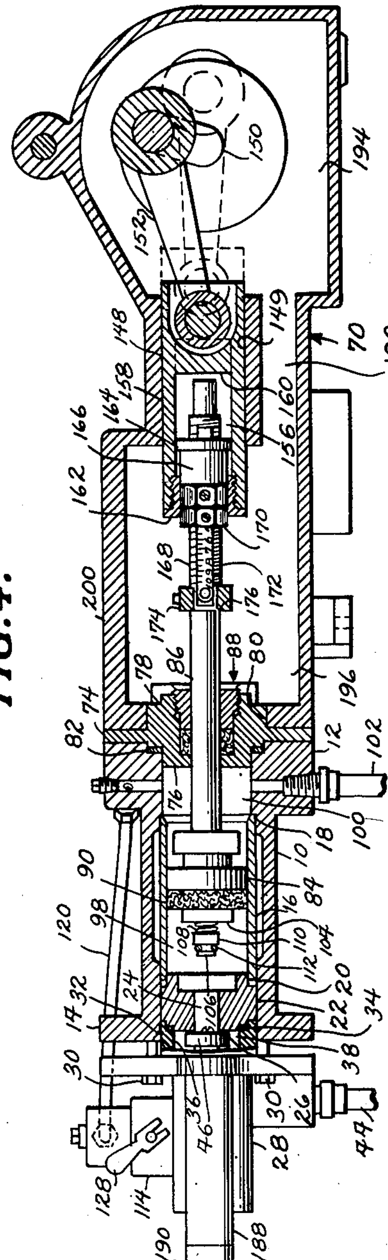


FIG. 4.

INVENTORS
DONELSON B. HORTON
DOUGLAS JOHNSTON

BY Cushman, Darby & Cushman
ATTORNEYS

Oct. 29, 1957 D. B. HORTON ET AL 2,811,108

VARIABLE-CAPACITY METERING PUMP

Original Filed May 17, 1954 4 Sheets-Sheet 3

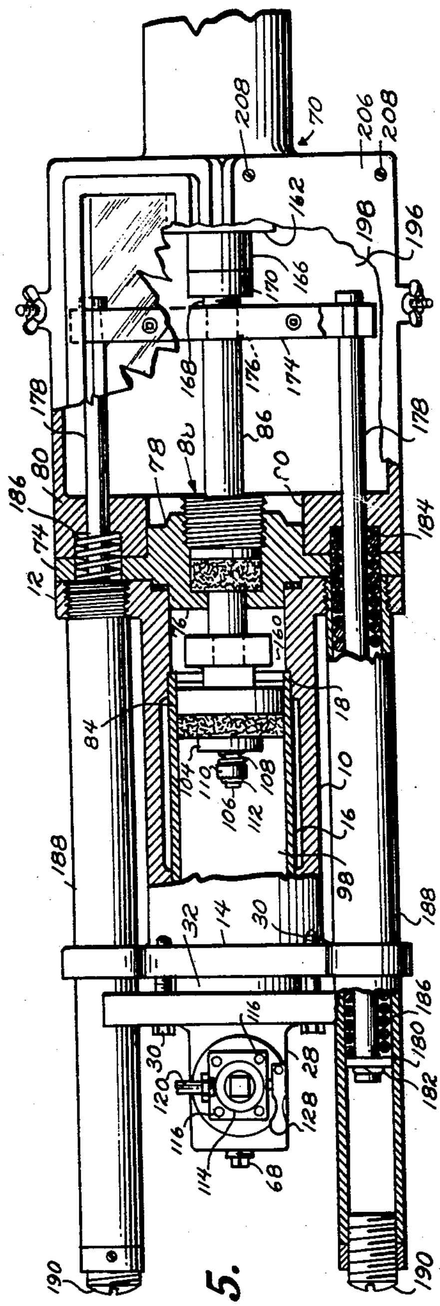


FIG.5.

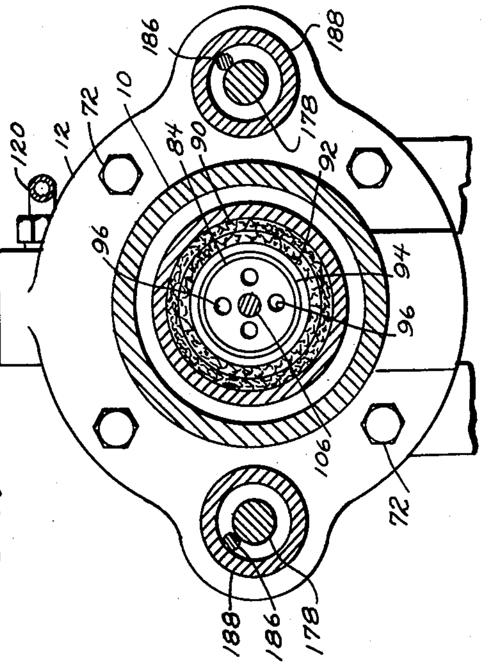


FIG.7.

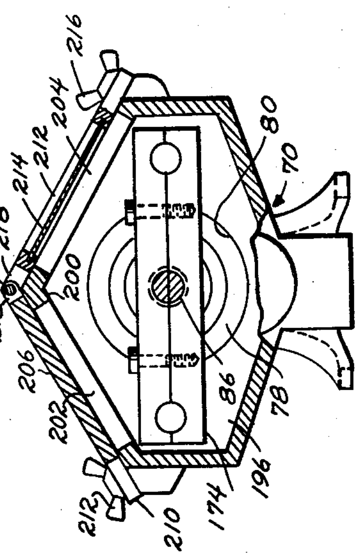


FIG.6.

INVENTORS

DONELSON B. HORTON
DOUGLAS JOHNSTON

BY Cushman, Darby & Cushman

ATTORNEYS

FIG. 8.

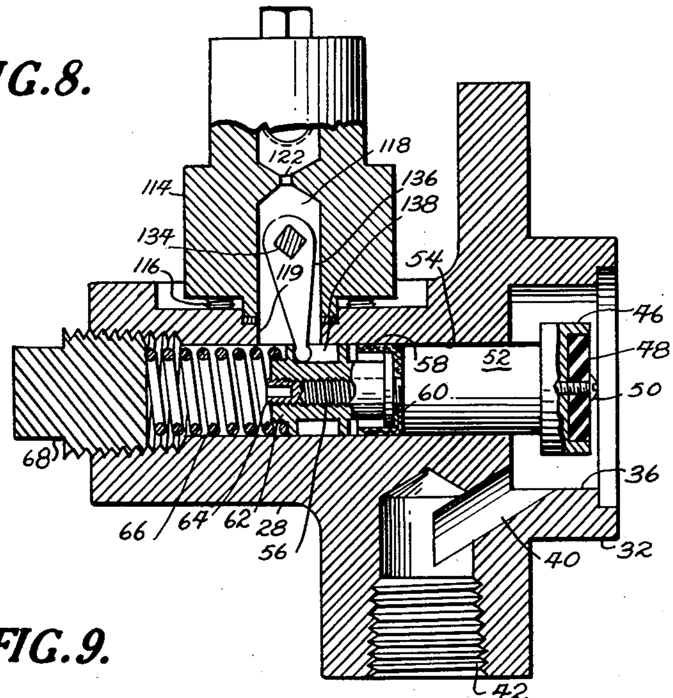
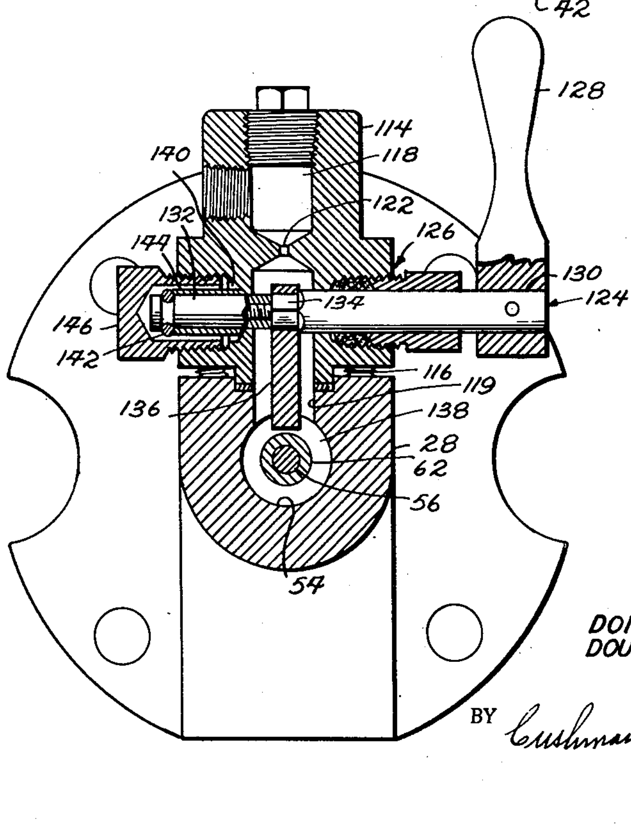


FIG. 9.



INVENTORS
DONELSON B. HORTON
DOUGLAS JOHNSTON

BY Cushman, Darby & Cushman
ATTORNEYS

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VARIABLE-CAPACITY METERING PUMP

Donelson B. Horton and Douglas Johnston, Huntsville, Ala., assignors to John Blue Company, Incorporated, Huntsville, Ala., a corporation of Alabama

Original application May 17, 1954, Serial No. 430,087, now Patent No. 2,771,846, dated November 27, 1956. Divided and this application February 20, 1956, Serial No. 566,473

3 Claims. (Cl. 103—38)

This invention relates to variable-capacity metering pumps, and more particularly to pumps for metering a pressurized normally-gaseous liquid. This invention is an improvement on the metering pump disclosed and claimed in the copending application of John Blue, Serial No. 80,957, filed March 11, 1949, now Patent No. 2,696,785. This application is a division of our application Serial No. 430,087 filed May 17, 1954, now Patent No. 2,771,846, granted November 27, 1956.

The pump disclosed in the aforementioned applications is used principally to accurately meter anhydrous ammonia for application to the soil for agricultural purposes. While very satisfactory for its intended purpose in actual practice, the pump is subject to several improvements which both increase its metering accuracy and reduce maintenance expense. The pump disclosed in the above applications is of the positive displacement type, having a piston or pump plunger provided with an inlet check valve and reciprocable in a pumping cylinder. The cylinder is provided with an outlet check valve that is loaded by the pressure of the source of supply of the liquid being pumped independently of the discharge from the pump. The piston rod or pump rod is intermittently engaged and pushed inwardly of the pumping chamber for a discharge or pumping stroke by either a reciprocating crosshead driven by a connecting rod and crankshaft arrangement, or a rotating cam. The suction stroke of the piston rod, i. e., movement of the rod outwardly of the pumping chamber, is effected by springs and also by the pressure of the source of supply of the liquid being pumped. The pump is of variable capacity, and the capacity is adjustable by means which serve to limit the stroke of the piston rod.

In the aforedescribed pump, when its capacity is adjusted to a setting below maximum, there is lost-motion engagement between the reciprocating crosshead or rotating cam and the piston rod. It also will be seen that, as the setting of the pump is progressively adjusted toward minimum, the extent of lost motion in the aforementioned engagement increases correspondingly. Further, it will be seen that, since the suction stroke of the pump is effected solely by the aforementioned springs and the pressure of the source of supply of the fluid being pumped, the suction stroke is not accomplished by a positive drive. In the event that the packing gland for the piston or pump rod is too tight, the piston rod may tend to stick so that a full suction stroke, at the adjusted setting of the pump, is not obtained, with consequent metering inaccuracies. The same result can possibly be obtain at higher rates of pump operation, in that a full suction stroke may not occur before the piston rod is again engaged by the positive drive for its discharge stroke. Furthermore, because the suction stroke of the pump is not obtained by a positive drive, the drive for the pump is under an intermittent or pulsating load.

Additionally, the pump shown in the aforementioned applications has a valve-controlled purging passageway

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extending between the pumping chamber and the outlet chamber at the discharge side of the outlet check valve. The valve controlling the passageway must, of course, be constructed to withstand the full pressure developed within the pumping chamber.

In addition to the foregoing, the pump shown in the aforedescribed applications has a partially-open crankcase so that a portion of the piston or pump rod, and the mechanism for adjusting its stroke, are exposed. Since the pump is utilized by farmers, there is a strong likelihood of dirt or trash accumulating in the aforedescribed exposed portion in the crankcase with resultant undue wear and abrasion of the thus-exposed moving parts of the pump.

Therefore, it is an object of this invention to provide a variable-capacity metering pump of the reciprocating type wherein pulsations in the load on the pump drive are smoothed out as much as possible and the evenness of the load on the pump drive is at maximum.

It is another object of this invention to provide a pump of the type described that is accurate at higher rates of operation.

It is another object of this invention to provide means for purging the pumping chamber of the type described which eliminates the need for a high-pressure valve.

It is another object of this invention to provide a pump of the type described that has a housing completely enclosing all moving parts of the mechanism for adjusting the capacity of the pump.

Other objects and advantages of the invention will become apparent from the following description and accompanying drawings, in which:

Figure 1 is a side elevational view of a metering pump embodying this invention.

Figure 2 is a plan view of the pump shown in Figure 1, with parts broken away.

Figure 3 is a longitudinal sectional view taken on lines **3—3** of Figure 2 and showing the pump adjusted to its maximum capacity.

Figure 4 is a view corresponding to Figure 3, but showing the pump adjusted to a less than maximum capacity.

Figure 5 is an enlarged fragmentary top plan view of the pump shown in Figure 2, with parts broken away to illustrate details.

Figure 6 is an enlarged vertical sectional view taken on line **6—6** of Figure 1.

Figure 7 is an enlarged, vertical, sectional view taken on line **7—7** of Figure 3.

Figure 8 is an enlarged, fragmentary, sectional view taken on line **8—8** of Figure 2.

Figure 9 is an enlarged fragmentary sectional view taken on line **9—9** of Figure 1.

Referring now to the drawings, there is shown a pump embodying this invention. The pump includes an open-ended cylinder **10** having exterior circumferential end flanges **12** and **14** and a liner **16** fitting against an interior shoulder **18**. Engaging against the other end of the liner **16**, with a gasket **20** therebetween, is a plug-like member **22** having a central valve port **24** therethrough provided with an annular valve seat **26** at its outer end. A flanged cylinder head **28**, secured by cap screws **30** to the cylinder flange **14**, has an annular boss **32** fitting into one end of the cylinder **10** and engaging against the plug-like member **22**, with an appropriate gasket **34** therebetween to retain the member **22** and the liner **16** in proper position within the cylinder. The boss **32** is provided with a central circular recess **36** opposed to the valve seat **26** to form a discharge chamber **38** from which a passageway **40** leads to an interiorly-threaded opening **42** (Figure 8) in the cylinder head **30** for connection to a discharge conduit or hose 44. A valve disc 46 having a recessed resilient valve washer 48 secured thereto by a screw 50 is adapted for seating engagement with the valve seat 26. The valve disc 46 has a stem 52 slidably guided in a bore 54 in the cylinder head 28 for reciprocating seating and unseating movement of the valve disc. At its rearward end, the valve stem 52 has a reduced and threaded extension 56, with a flexible sealing cup 58 and a rigid cup-retainer washer 60 secured thereon by an elongated nut 62 having a locking set screw 64 threaded into the other end thereof. A coil compression spring 66 is engaged between the nut 62 and a plug 68 threaded into the outer end of the bore 54 for urging the valve washer 48 to seat.

The flange 12 at the other end of the cylinder 10 is secured to an open end of a crankcase housing 70, as by cap screws 72, with a stuffing box plate 74 clamped therebetween. The stuffing box plate 74 has a circular portion 76 extending into the corresponding end of the cylinder 10 to close the same and a circular portion 78 on its opposite face extending into a circular opening 80 in the crankcase housing 70 to close the same. An appropriate sealing gasket 82 is interposed between the cylinder 10 and the stuffing box plate 74. Reciprocable within the cylinder liner 16 is a valved pump plunger or piston 84 having a piston rod or pump rod 86 threadedly engaged with one end thereof and slidably extending through a stuffing box 88 in the stuffing box plate 74 and into the crankcase housing 70. The piston 84 is provided with a cup seal 90 secured in place by a cup-retainer washer 92 and snap ring 94 (Figure 3), and has a plurality of ports 96 extending therethrough from end to end thereof. The piston 84 divides the cylinder 10 into a pumping chamber 98 and an inlet chamber 100 to which a suction line 102 is connected. The ends of the piston ports 96 which are exposed to the pumping chamber 98 are arranged in a circle and normally closed by a valve disc 104 reciprocable on a valve stud 106 centrally threaded into the corresponding end of the piston 84. The valve disc 104 is urged to seat against the end of the piston 84 to close the valve ports 96 by a coil compression spring 108 surrounding the stud 106 and retained thereon by a retainer washer 110 held on the stud by a snap ring 112.

In operation, the pump is mounted on a tractor on a towed type of vehicle (not shown) and driven by mechanism later described by a drive from a ground-engaging wheel of the vehicle. The liquid to be pumped, e. g., anhydrous ammonia, is contained in a supply tank (not shown), also mounted on the vehicle. Liquid anhydrous ammonia, when confined, develops considerable pressure at ordinary room temperature, and when exposed to the heat of the sun in the aforementioned supply tank, develops an even greater pressure. Hence, this pressure of the liquid being pumped would require an extremely heavy and strong spring 66 for the outlet check valve 46 of the pump, were such spring the only instrumentality used to urge the outlet check valve to seat. To avoid this difficulty, the outlet check valve 46 of the pump is loaded by the pressure of the source of supply of the fluid being pumped. To this end, a housing 114 is secured, as by cap screws 116, to the top of the cylinder head 28 and has a bore 118 (Figures 8 and 9) aligned with a radial port 119 in the cylinder head that is in communication with the bore 54 in the cylinder head rearwardly of the cup seal 58 on the valve stem 52. A conduit 120 connected to the inlet chamber 100 of the pump and to the bore 118 in the housing 114 conducts the pressure of the fluid being pumped to the bore 54 at the rear of the valve stem 52, to thus constantly urge the valve 46 to seat. Preferably, the diameter of the valve stem 52 and the valve port 24 are equal, so that the valve 46 is substantially pressure-balanced. Also, the bore 118 preferably includes a choke orifice 122 therein, for reasons described in the above-mentioned copending applications.

The pump thus far shown and described is substantially the same as that disclosed in the aforementioned copending applications.

Before the start of a pumping operation, because the pump is normally exposed to the heat of the sun, as aforedescribed, the pumping chamber 98, inlet chamber 100, and the suction line 102 leading thereto are apart to be full of gas, or a mixture of gas and liquid. Since a mixture of gas and liquid cannot be metered with any degree of accuracy by the pump, it usually is essential to purge the pumping chamber 98, inlet chamber 100, and the supply line 102 leading thereto of gas before the starting of a pumping operation and to fill such chambers and line with liquid. For this purpose, a two-part operating shaft 124 (Figure 9) extends through a stuffing box 126 in the housing 114 transversely through the bore 118 and has a handle 128 on one end thereof for rocking the same. The two parts 130 and 132 of the shaft 124 have threaded connection within the bore 118, and the corresponding end of the part 130 of the shaft is square, as at 134, for the rigid mounting of a lever 136 thereon that depends through the bore 118 and port 119 into an annular groove 138 in the nut 62. Accordingly, rocking movement of the shaft 124 engages the lower end of the lever 136 with a side wall of the groove 138 to unseat the valve 46. Upon release of the handle 128, the spring 66 immediately reseats the valve 46 with a normal seating force. The part 132 of the shaft extends into an exterior counterbore 140 in the housing 114 and is retained therein by a snap ring 142 engaging the outer end of a sleeve 144 surrounding the shaft part 132, the inner end of the sleeve engaging against the bottom of the counterbore. Preferably, a cap-like plug 146 is threaded into the counterbore 140 to prevent leakage.

For driving the pump, a crosshead 148 (Figures 3 and 4) is reciprocably mounted in a longitudinal guiding bearing 149 formed interiorly of the crankcase housing 70. The crosshead 148 is driven by a crankshaft 150, transversely journaled in the housing 70, and connected to the crosshead by a connecting rod 152. One end of the crankshaft 150 projects out of the housing 70 for drive by a chain 154, engaging a sprocket on a ground-engaging wheel (not shown) of the vehicle on which the pump is mounted and a sprocket (not shown) rotatably mounted on the outer end of the crankshaft. Appropriate clutch mechanism (not shown), such as that shown in the aforementioned applications, is employed to engage and disengage the crankshaft sprocket into and from driving connection with the crankshaft 150.

The crosshead 148 has a cylindrical recess 156 at the forward end thereof to define an integral forwardly-projecting sleeve 158 coaxial with and receiving the rearward end of the piston rod 86. The bottom 160 of this recess 156 is flat for engagement with the correspondingly-flat end of the piston rod 86 to intermittently push the latter inwardly of the pumping chamber 98 for a pumping or discharge stroke of the piston 84. Threaded into the end of the sleeve 158 is a collar 162, the inner end of which forms an abutment for engagement with a corresponding abutment, formed by a circumferential flange 164 on a nut 166 engaging a threaded portion 168 of the piston rod 86. A lock nut 170 is also threaded onto the piston rod 86 for engagement with the forward end of the nut 166. A side of the threaded portion 168 of the piston rod 86 is flattened and has an elongated scale 172 secured thereto for cooperation with the forward end of the lock nut 170 to indicate the relative position of the adjusting nut 166 with respect to the piston rod 86. This scale 172, as will become apparent, can be graduated to indicate the capacity of the pump, i. e., the adjusted capacity of the pump between maximum and minimum or zero capacity.

In the showing of Figure 3, the pump is adjusted to full capacity; i. e., at the beginning of a discharge stroke of the crosshead 148, the bottom 160 of the recess 156 engages the end of the piston rod 86 so that a pumping stroke of maximum length will be effected. Likewise, it will be seen that the flange 164 on the nut 166 and the collar 162 are engaged so that on the return stroke of the crosshead 148 the length of the suction stroke of the piston 84 will be at a maximum.

Referring now to Figure 4, it will be seen that in this showing the adjusting nut 166 has been threaded rearwardly on the piston rod 86, so that in its return stroke the crosshead 148 will not pull the piston rod 86 rearwardly as far as when the nut 166 is in the position shown in Figure 3. Accordingly, as the crosshead 148 starts its discharge stroke, it moves a considerable distance before engaging the end of the piston rod 86 to effect the discharge stroke of the same. Consequently, a lost-motion connection exists between the piston rod 86 and the crosshead 148 at any position of adjustment of the nut 166 between minimum and maximum capacity of the pump.

As described before, the inlet chamber 100 and the pumping chamber 98 of the pump are under considerable pressure even during the suction stroke of the piston 84. This pressure, of course, urges the piston rod 86 outwardly of the pump chamber 98. Thus, while once the crosshead 148 engages the piston rod 86 the crosshead and the crankshaft 150 and its drive are under considerable load during the pumping stroke of the crosshead, unless otherwise provided for, the crosshead and its drive are under no load on the suction stroke. Therefore, unless otherwise provided for, the drive for the pump would be under a pulsating load, which would result in considerable wear and tear and possible breakage of some of the parts of the pump drive.

In order to eliminate this difficulty, a two-part transverse crossbeam 174 has its upper and lower parts clamped onto a reduced portion of the piston rod 86 and engaging against a rearwardly-facing shoulder 176 thereon. Clamped between the two parts of the crossbeam 174, at each end thereof, is a necked portion of a rod 178 which extends parallel to the axis of the piston rod 86 through aligned apertures in the crankcase housing 70 and in the stuffing box plate 74 and outwardly along the cylinder 10. On the outer end of the rod 178 is a spring-retainer washer 180, retained by a snap ring 182, and between the washer 180 and the bottom 184 of a counterbore extending through the stuffing box plate 74 and into the housing 70 is a coil compression spring 186. Preferably, each spring 186 is enclosed in a separate tube 188 having one end thereof threaded into the flange 12 (Figure 5) on the end of the cylinder 10 and the other end thereof closed by a threaded plug 190. The intermediate portion of each tube 188 is supported in an apertured ear 192 on the flange 14 on the other end of the cylinder 10.

From the aforedescribed construction, it will be seen that the springs 186 oppose the suction stroke of the piston rod 86 so that the drive for the pump will be under a load during the suction stroke of the latter. At the same time, the springs 186 store up energy to somewhat relieve the load on the pump drive during the discharge or pumping stroke of the pump. Thus, when the pump is adjusted for less than maximum capacity and the crosshead 148 starts its discharge stroke, the springs 186 tend to maintain the flange 164 on the adjusting nut 166 in engagement with the end of the collar 162 for an appreciable extent of the discharge stroke of the crosshead 148 and until the pressure in the pump chamber 98 is built up to such an extent that the springs 186 cannot overcome the same. At this time, the bottom 160 of the recess 156 in the crosshead 148 catches up with and engages the end of the piston rod 86 to effect a positive pumping stroke of the latter. Therefore, it will be seen that jars and impacts occasioned by the lost-motion connection between the piston rod 86 and the crosshead 148 are substantially lessened and minimized by the action of the springs 186.

Referring now to Figures 1 to 6 of the drawings, it will be seen that the crankshaft housing 70 includes two

chambers 194 and 196 joined by a lower passageway 198 beneath the crosshead bearing 149, the chamber 194 serving as an actual crankcase and the chamber 196 serving as a housing for the pump-capacity-adjusting mechanism and for the exposed portion of the piston rod 86 and exposed ends of the spring rods 178. In operation, the crankcase chamber 194 normally has oil therein which can flow, via the passageway 198, into the chamber 196 to maintain the moving parts therein in a lubricated condition. The top of the chamber 196 is open, save for a longitudinally-extending bridge member 200, and the upper edges of the end walls of the chamber 196 are inclined laterally and downwardly to provide two upper openings 202 and 204 (Figure 6) to the chamber, one on each side of the bridge member 200, the upper edge of each opening lying in a downwardly and laterally-inclined plane. Closing the opening 202 is a closure plate 206, secured to the housing 70, as by screws 208. An apertured ear 210 at the lower edge of the closure plate 206 has a wing bolt 212 extending therethrough and into a tapped opening in the crankcase housing 70. The opening 204 on the other side of the bridge member 200 is closed by a similar closure plate 212 having a transparent window 214 therein for viewing the scale 172. The closure plate 212 is similarly secured in position by a wing bolt 216, but has no other securing screws. At their upper and adjacent edges, both closure plates 206 and 212 are provided with transversely-overlapping apertured ears 218 and are pivotally connected together by a longitudinally-extending pivot pin 220, so that either closure plate may be unfastened from the crankcase housing 70 and raised upwardly for inspection of the interior of the chamber 196 and the parts therein.

Considering again the mechanism for adjusting the capacity of the pump, it will be seen that at each discharge stroke the piston 84 is pushed inwardly of the pumping chamber 98 almost into engagement with the member 22, so that at each discharge stroke of the pump the volume of the pumping chamber 98 is reduced to a minimum. Because of this fact, even if some gas is formed or enters into the cylinder, the effect of such gas on the accuracy of metering of the pump is minimized. On the other hand, if the volume of the pumping chamber is not reduced to a minimum at each discharge stroke of the pump and gas is formed or enters into the pumping chamber, such gas might tend to accumulate until the pump became "gas-locked."

It thus will be seen that the objects of the invention have been fully and effectively accomplished. It will be realized, however, that various changes may be made in the specific embodiment shown and described for the purpose of illustrating the principles of the invention. Therefore, this invention includes all modifications encompassed within the spirit and scope of the following claims.

We claim:

1. A variable-capacity pump for accurately metering a pressurized fluid comprising: means defining an expansible pumping chamber having a movable wall; a reciprocable pump rod secured to said wall and extending outside said chamber for moving said wall inwardly and outwardly thereof; a fixed throw reciprocating driving member opposed to the outer end of said rod and engageable with said rod end to effect a discharge stroke thereof; means defining a sleeve extending from said member and enclosing the end portion of said rod; means defining a radially-inwardly-extending circumferential flange on said sleeve; means defining a radially-outwardly-extending circumferential flange on said rod within said sleeve engageable with said sleeve flange to effect a suction stroke of said rod, said rod flange means being threadedly mounted on said rod for axial adjustment therealong to vary the capacity of the pump; and a longitudinally-extending scale on said rod, cooperable

with reference means associated with said rod flange means for indicating the adjusted capacity of the pump.

2. In a variable capacity pump the combination comprising: means defining an expansible pumping chamber having a movable wall; a reciprocating pump rod secured to said wall and extending outside said chamber for moving said wall inwardly and outwardly thereof for discharge and suction strokes, respectively; a fixed-throw reciprocating driving member having an abutment surface engageable with the outer end of said rod for moving the latter inwardly of said chamber; a sleeve on said driving member enclosing said rod outer end and having a radially-inwardly extending flange; and a nut threaded on said rod and having a radially outwardly extending flange interposed between said surface and said sleeve flange and engageable by the latter for moving said rod outwardly of said chamber, rotation of said nut on said rod with resulting axial movement therealong serving to adjust the capacity of the pump, said nut being elongated and having a portion disposed outside said sleeve to facilitate access to said nut.

3. The structure defined in claim 2 including a housing completely enclosing the driving member, the sleeve, the nut, and that portion of the rod extending outside the chamber, said housing having an opening therein for access to the nut, and including a removable closure for said opening.

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