Jan. 19, 1971 H. SCHEFFER 3,556,690

MOTOR-DRIVEN PUMP FOR DELIVERING LIQUIDS AT A PRESSURE SUBSTANTIALLY CONSTANT AND INDEPENDENT FROM THE DELIVERY

Filed Aug. 21, 1968 4 Sheets-Sheet 1

Fig. 1.

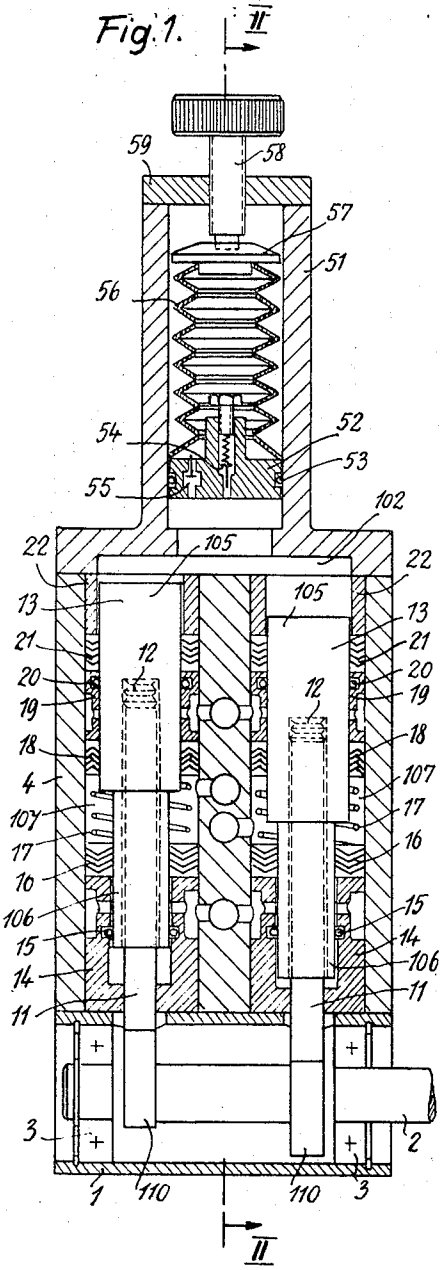
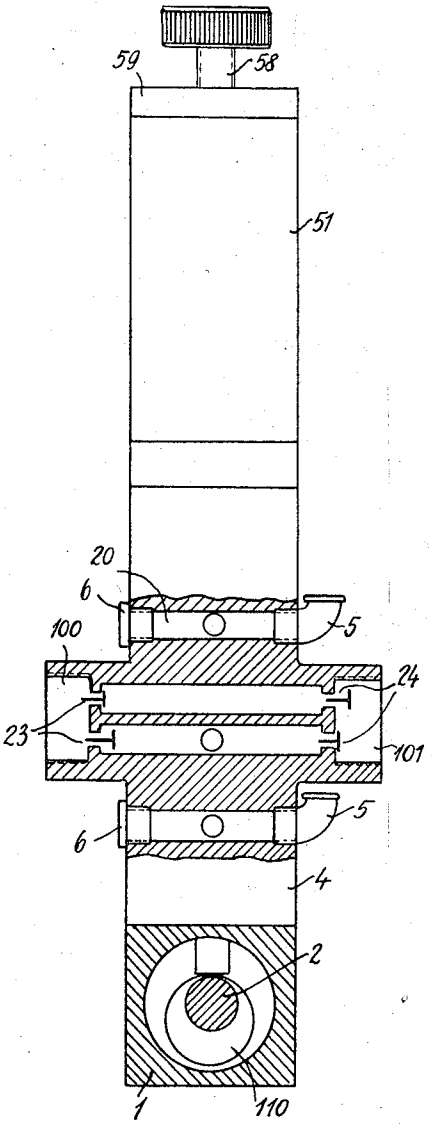


Fig. 2.



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Fig.3.

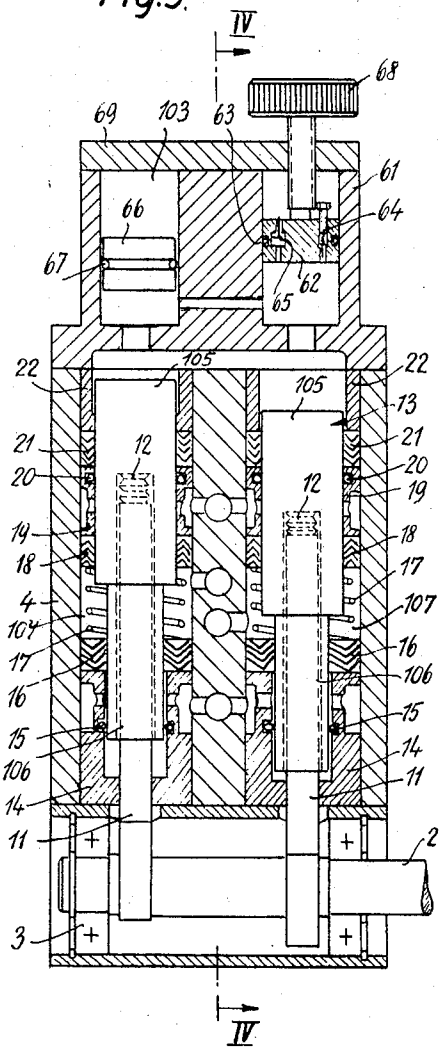
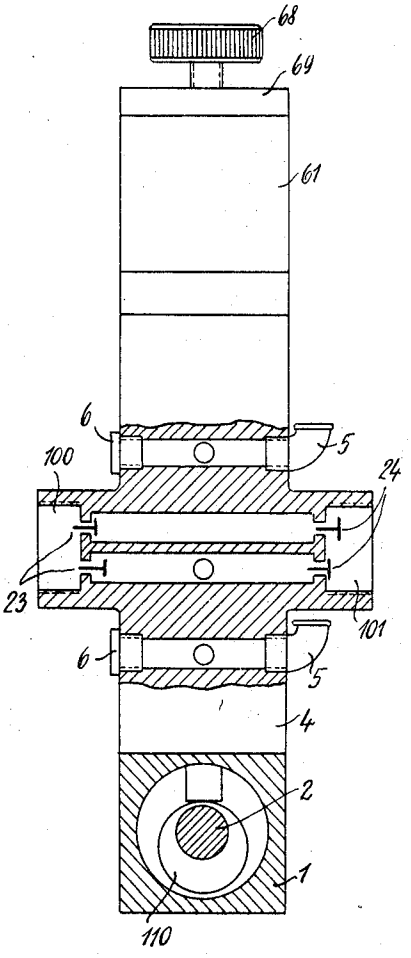


Fig.4.



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Fig. 5.

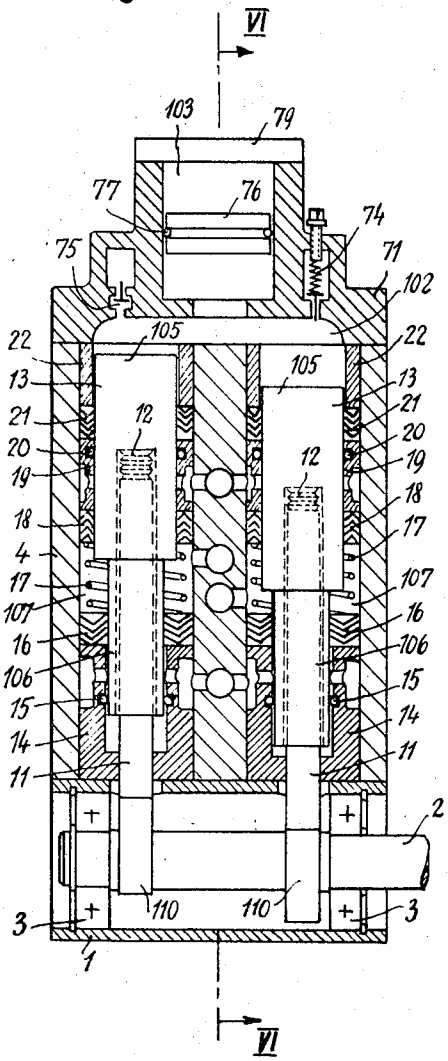
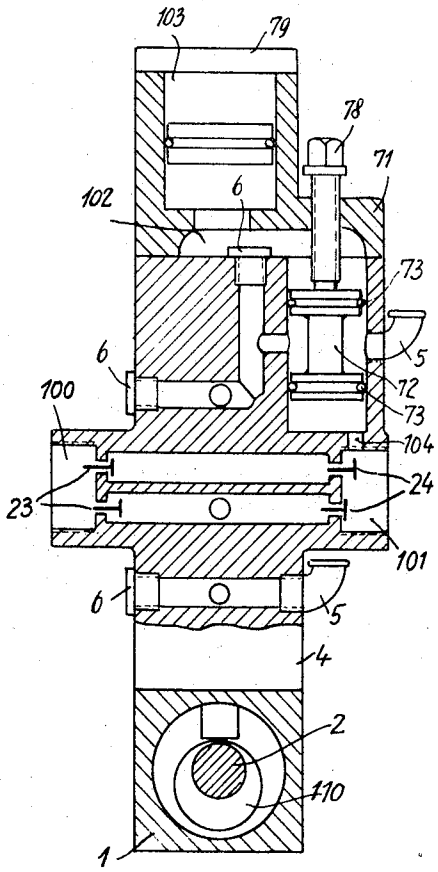


Fig. 6.



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Fig. 7.

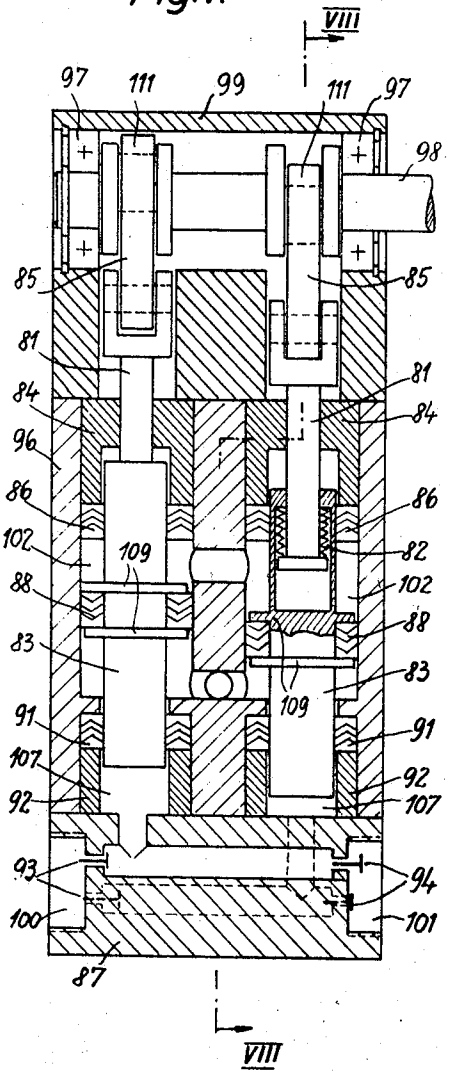
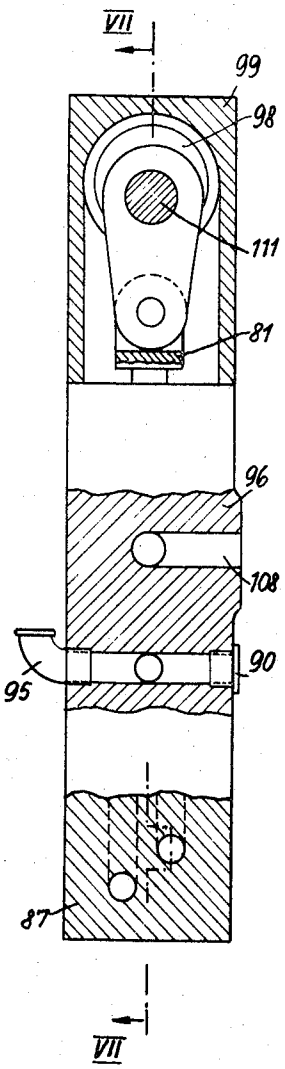


Fig. 8.



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3,556,690

MOTOR-DRIVEN PUMP FOR DELIVERING LIQUIDS AT A PRESSURE SUBSTANTIALLY CONSTANT AND INDEPENDENT FROM THE DELIVERY

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U.S. Cl. 417—471 8 Claims

ABSTRACT OF THE DISCLOSURE

A piston pump which delivers liquids at a pressure constant and independent from the quantity delivered. The pump cooperates with a control unit which allows automatic variation of the piston stroke with change of delivery, but without substantial change of discharge pressure. This stroke variation is performed by means of a yielding liquid connection between the piston performing the suction stroke and the piston performing the delivery stroke. The drive is resiliently coupled with the pistons during the suction stroke so that partial strokes are performed with a partial idling drive.

BACKGROUND OF THE INVENTION

The invention relates to a motor-driven pump for delivering liquids at a pressure substantially constant and independent from the quantity delivered per second, especially for lacquers and other substances for surface coating applying the airless process, i.e., without application of compressed air in the atomizing step.

Up to now, compressed air-operated pressure transmitters have been used for this purpose, because in the airless process one of the main prerequisites is a constantly available pressure independent from the quantity delivered per second. The low overall efficiency of a compressed-air operated airless apparatus, as well as the dependence from air compressor plants, make the construction of directly motor-driven high-pressure pumps appear to be suitable in this application field. Beside the control of the quantity delivered per second independent from pressure already mentioned, the new pump must also allow an adjustable working pressure.

SUMMARY OF THE INVENTION

In accordance with the invention, the problem is solved in that at least two freely displaceably arranged pistons are connected on the one side, with a common control chamber filled with a liquid pressurized by pressure means and, on the other side, are connected each via a suction and pressure valve with a suction line and a delivery line, and the delivery stroke of these pistons is performed by action from the control chamber side and their suction stroke is performed via a one-way connection from a driving source in such a manner that the drive pulses for the suction strokes of the pistons are uniformly distributed over a complete cycle of movement of the pistons. In this manner, the pistons always perform a stroke at a time which corresponds to the respective delivery. When this quantity drops to zero, the strokes performed by the piston also will be equal to zero. In this arrangement, the drive shaft continues to move making use of the one-way connections between the drive means and the piston.

Upon reduction of the quantity delivered per second the pressure means pressurizing the liquid in said control chamber will correspondingly reduce, however, constantly securing the delivery pressure while the respective quantity of delivery corresponds to the quantity of control liquid which is displaced in the control chamber by the piston performing the suction stroke to the cylinder of the other piston; thereby the other piston is indirectly driven to perform its delivery stroke.

In principle, the driving method for the plurality of pistons provided in accordance with the invention is of no importance. More than two, for instance, three or four pistons may be provided. It is also possible, for example, to use several motors which drive synchronously the pistons in the manner indicated and in dephased order with respect to each other. It is also possible to provide several shafts driven by one motor, the synchronous running of which is secured by interposed gears. As a rule, however, it will be recommendable to drive the pistons to perform their suction stroke by means of one common shaft driven by a motor.

Preferably, two pistons are provided which are driven in opposite directions at a time by means of two eccentric cams arranged on the shaft, said cams being dephased with respect to each other through 180°.

Further improvements and suitable modifications of the invention are described by way of the enclosed drawing which shows some examples of embodiments of the invention in a schematic representation.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 shows a longitudinal sectional view of a high pressure pump constructed in accordance with the invention,

FIG. 2 shows a partially sectional side view of the pump taken on line II–II of FIG. 1,

FIG. 3 shows a longitudinal sectional view of a second embodiment of a high pressure pump designed in accordance with the invention,

FIG. 4 shows a partially sectional side view of the pump of FIG. 3 taken on line IV—IV of FIG. 3,

FIG. 5 a longitudinal sectional view of a third embodiment of a pump constructed in accordance with the present invention,

FIG. 6 a partially sectional view taken on line VI—VI of FIG. 5,

FIG. 7 a longitudinal sectional view of a fourth embodiment of the invention, and

FIG. 8 a partially sectional side view taken on line VIII—VIII of FIG. 7.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

With the embodiments in accordance with FIGS. 1 and 2, the eccentric shaft **2** is rotatably supported in ball bearings **3** provided in the crankcase **1**. The driving motor proper is not shown. Eccentric cams **110** are angularly offset from each other through 180°; the crankcase **1** is fixed to the pump casing **4**; the eccentric cams **110** act on the differential piston **13** via piston rods **11** and cup springs **12**. In the piston rod guides **14**, there are disposed O-rings **15**. The gaskets **16** and **18** are put under stress by means of springs **17** and seal the pump against the flow medium; the leakage chambers **19** are provided with O-rings **20** inside. The gaskets **21** are supported against a control cylinder **51** by brushes **22**. In the control cylinder **51**, a control piston **52** is sealed by means of an O-ring **53** which closes a control chamber **102** into which the two differential pistons **13** are received. The piston **52** contains an excess-pressure valve **54** and the refilling valve **55**. Cup springs **56** are disposed above the piston **52** which are supported by an adjusting screw **58** via a pressure plate **57**, said screw **58** being screwed into the cover **59** of the control cylinder **51**. The filler connections **5** permit the introduction of

a rinsing or cleaning liquid, the drain of which is prevented by the closure screws **6**. The suction valve **23** and the pressure valves **24** open into a common suction line **100** and a common pressure line **101**, respectively. The pistons **13** are composed of a piston portion **105** with large cross section and a piston portion **106** with small cross section. The effective annular surface between both portions is located in a working chamber **107**.

In the embodiment shown in FIGS. 3 and 4, the pump proper is the same as compared with that shown in FIG. 1 and 2 so that like reference numerals have been used for like parts. The control unit, however, is different. A control housing **61** is fastened on the pump casing **4**. A control piston **66** is sealed by an O-ring **67** against a bore disposed in the control housing **61**, said control piston closing a control cylinder **103** which may be filled at its upper portion with a pressurized gas. An adjusting piston **62** is sealed by an O-ring **63** against a second cylinder disposed in the control housing **61** and connected to the control chamber **102**; the adjusting piston contains an excess-pressure valve **64** and the refilling valve **65** and is supported by means of an adjusting screw **68** rotatably arranged in the cover **69**.

In the embodiment according to the FIGS. 5 and 6 the high pressure pump is again unchanged and is identified by the same reference numerals. In the pump casing **4**, however, there is additionally disposed an adjusting piston **72** sealed the control chamber **102** by means of O-ring **73**, the movement of said piston **72** being limited on one side by means of an adjusting screw **78**. The adjusting piston **72** is under the influence of the pressurized liquid delivered by the pump via conduit **104**. It is also possible to use another pressure medium. The filler connection **5** for the rinsing liquid is arranged in a somewhat different position as compared with the embodiments shown in FIGS. 1 to 4. A control cylinder with a control piston **76** is disposed on the pump casing **4**, said control piston **76** separating the gas chamber **103** against the control chamber **102** by means of an O-ring **77**. The control cylinder cover **79** closes the control cylinder at the top. An excess-pressure valve **74** and a refilling valve **75** are seated in an annular channel.

In the embodiment shown in FIGS. 7 and 8, the crankcase **99** encloses the crankshaft **98** rotatably supported in ball bearings **97**. The crankcase **99** is rigidly connected with the pump casing **96**. In the two longitudinal bores of the pump casing **96**, are disposed the piston rod guides **84**, the gaskets **91** and the bushes **92**. The piston rods **81** are connected with the crankshaft **98** via the connecting rods **85**. The pistons **83** are sealed in the bores of the pump casing **96** by gaskets **88**.

The cranks **111** of the shaft **98** drive, via the connecting rods **85**, the piston rods guided on a straight line by means of the guides **84**. The piston rods **81** may displace the pistons **83** via cup springs **82**. The valve case **87** is rigidly and tightly screwed to the pump casing **96**. The suction valves **93** and the pressure valves **94** open into a common suction line **100** and a common pressure line **101**, respectively. The control chamber **102** is disposed between the gaskets **86** and **88** which chamber is filled, in particular, with oil. The control chamber **102** is in communication with one of the three control units shown in the FIGS. 1 to 6 via a lateral bore **108**.

The pump is substantially alike in the embodiments shown in FIGS. 1 to 6. With rotation of the crankshaft the connecting rods **11** are guided upwardly and take along with them the differential pistons **13** via the cup spring **12**. Thereby the volume of the working chamber **107** is expanded between the gaskets **16** and **18**; the suction valves **23** open, and the flow medium to be delivered is drawn in. By the angular offset arrangement of the eccentric cams through 180° it is possible for the first piston **13** to move downward during the upward

movement of the second differential piston **13**. This downward movement is effected by the upwardly moving second piston due to displacement of the pressurized fluid present above the second differential piston **13** in the control chamber **102**, so that the downwardly moving first piston **13** is indirectly driven by the pressure fluid displaced in the control chamber **102**. In the downward movement, the ring chamber **107** between the gaskets **16** and **18** is reduced, and a corresponding quantity of flow medium to be delivered is pressed out through the pressure valves **24**.

The oil charge above the differential pistons **13** reaches approximately as far as one half the height of the control cylinder **51**, with the oil above piston **52** being pressureless. The oil pressure may be adjusted by means of the screw **58** via cup spring **56**.

In the case of no or low delivery, both differential pistons **13** move into the upper dead center position and remain there. The excess quantity of oil escapes into the control cylinder **51** and presses the control piston **52** upwardly through a corresponding distance. Due to the ratio of this path to the overall spring path, the pressure increase resulting with lower quantities of delivery per second may be kept within as small limits as may be desired. The piston rods **11** now run empty up and down in the pistons. The refilling valve **55** serves to balance possible leakage losses. The rinsing liquid to be introduced through the filler connection **5** makes it possible at any time to recognize the condition of the gaskets **16**, **18** and **20**.

The operation of the control unit shown in FIGS. 3 and 4 is similar to that shown in FIGS. 1 and 2. The cup spring **56** is replaced by a gas filling the control cylinder **103** above control piston **66** to which gas filling, if desired or required, may be given a precompression. The pressure adjustment is effected via an adjusting piston **62** by means of a screw **68**. With no or partial output, the displaced oil volume will increase the pressure of the gas included above the piston **66** in control cylinder **103**.

The control with the embodiment shown in FIGS. 5 and 6 takes place in a similar manner as shown in FIGS. 3 and 4, however, with the exception that for the generation of higher pressures the adjusting piston **72** is adjusted by means of a servo effect of the flow medium to be delivered. A gas may be present in control cylinder **103** above the control piston **76** which gas is precompressed if desired or required. The underside of the adjusting piston **72** is under action of the flow medium to be delivered through a small bore **104** provided downstream of the pressure valves **24**.

By the selection of a suitable ratio of the piston surfaces on one side exposed to chamber **107** with the flow medium pressure acting thereon and on the other side at chamber **102** with the oil pressure acting thereon the pressure of the flow medium to be delivered may be higher than that of the oil in the control chamber **102**, so that, when the adjusting screw **78** is screwed higher, the adjusting piston **72** is urged upwardly thereby increasing the gas pressure in control cylinder **103** above the control piston **76**, which in turn causes an increase of the oil pressure in the control chamber **102** and therewith also of the discharge pressure. A decrease in pressure may take place under reverse conditions.

With all three control modifications, the full pressure is always available while the performance delivered from the crank shaft corresponds only to the actual delivery. With partial output of flow medium, the strokes of the differential pistons **13** are also performed only partially.

The principle used with the embodiment shown in FIGS. 7 and 8 is the same as in the FIGS. 1 to 6 with the exception that instead of a compression driving movement, a tension driving movement has been selected. In this operation, the rotation of the crankshaft **98** is acting via the connecting rods **85** and the piston rods **81** on the cup spring **82** and thus on the pistons **83**.

The medium to be delivered is sucked in through the suction valve **93** up to the gaskets **91** and is pumped through the pressure valves **94**. The advantage of this embodiment especially resides in that the delivery part is separated from the control and driving units of the pump by only one rinsing medium chamber which may be charged through the filler connection **95**. The cost of manufacture of the driving mechanism is somewhat higher with this embodiment. Also in this embodiment, the pistons **83** follow the movements of the piston rods **81** only so far as is admitted by the output of the medium to be delivered. A correspondingly large space has been left free in the pistons **83** below the piston rods **81** for the necessary idle stroke. The control takes place exactly as with the embodiments shown in FIGS. 1 to 6.

With the embodiments according to FIGS. 1 to 6, the full large front areas of the pistons **13** extend into the oil-filled control chamber **102**, while in the working chambers **107** the smaller annular surfaces are under the action of the flow medium. With the embodiment in accordance with FIGS. 7 and 8, a larger diameter piston **109** is provided on the piston **83** which is sealed by the gasket **88**. The annular surfaces between the pistons **83** and **109** is larger than the surface of the piston **83**. As the annular surface is effective in the control chamber **102** and the surface of the piston member **83** is effective in the working chamber **107**, here as well as with the embodiments according to FIGS. 1 to 6, a pressure transformation takes place in such a manner that the pressure downstream from the pressure valves is greater than the pressure in the control chamber.

In the case of other embodiments it may be suitable to invert the ratio of the piston surfaces so that the pressure in the control chamber **102** is greater than the pressure in the delivery line **101**.

A special advantage of the subject matter of this invention consists in that the control chamber is completely separated from the working chamber. The liquids and suspensions which are delivered when performing the airless process, for instance paints etc., are compounded to a considerable extent with solids, for instance, solid pigments which may be exert considerable wearing and abrasive effects. Also the pressures are rather high and lie, for example, in the order of 150 kg./cm.^{2}. Under these circumstances, it will have an especially favourable effect that the control chamber has no connection or contact with the medium to be delivered but is filled with a hydraulic oil of a suitable composition.

What I claim is:

1. A pump characterized by its ability to pump variable quantities of liquids at a substantially constant pressure comprising, in combination, a pump casing, at least first and second piston-receiving cylinders defined in said casing, first and second pistons axially slidably received within said first and second cylinders, respectively, said cylinders each being defined by a first chamber and a second chamber axially spaced from said first chamber, first and second pressure faces defined upon each piston sealingly located within said first and second chamber of the associated cylinder, respectively, said faces of a common piston being disposed in opposite axial directions with respect to the axis of the associated piston, liquid supply passage means communicating with said first chambers, a common liquid discharge passage means communicating with said first chambers, check valve means located in said supply and discharge passage means, alternating direction producing power driven drive means, first and second piston rod means in driven engagement with said drive means, lost motion means interposed between said first and second piston rod means and said first and second pistons, respectively, for selectively axially and alternately moving said pistons in the axial direction to produce a suction stroke under the influence of said drive means and draw liquid into said first chambers, means defined in said casing establishing communication between said second chambers and said second pressure faces, a liquid accumulator communicating with said second chambers, and biasing means associated with said accumulator imposing a predetermined pressure on liquid therein whereby the pressure acting on the liquid within said accumulator and second chambers and imposed on said second pressure faces solely produces the force on said pistons to axially move said pistons in the direction which produces pressurization of the liquid within said first chambers.

2. A pump in accordance with claim **1**, wherein said drive means includes a rotatable shaft, and eccentric drive surfaces defined on said shaft adapted to engage said piston rods.

3. A pump in accordance with claim **2**, wherein two pistons are located in said casing and two eccentric drive surfaces are defined on said shaft angularly displaced approximately 180° with respect to each other.

4. A pump in accordance with claim **1**, wherein said lost motion means include springs interposed between said piston rods and said pistons.

5. In a pump as in claim **1**, wherein said accumulator includes volume adjustment means for varying said predetermined pressure of said accumulator and varying the pressurization of the liquid within said first chambers.

6. In a pump as in claim **5**, wherein said volume adjustment means comprises a variable volume chamber communicating with said accumulator, and adjustable volume means within said variable volume chamber.

7. In a pump in accordance with claim **1**, wherein said first and said second piston pressure faces have different effective areas whereby a pressure differential exists between said second chambers and said first chambers during pressurization of said first chambers by the liquid pressure acting upon said second faces.

8. In a pump in accordance with claim **7**, wherein the area of said first faces of said pistons are larger than the area of said second faces.

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417—439, 533, 539, 568.