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[54] **PUMPS AND PAINTING INSTALLATIONS**

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[51] **Int. Cl.** **F04b 49/00**

[58] **Field of Search** 417/214, 274, 501, 437, 417/464

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[57] **ABSTRACT**

A pump assembly which is particularly suitable for supplying liquid to a direct pressure spray gun (i.e., an "airless" spray gun which does not require additional air to atomize such liquid) has pumping cylinder and piston members which deliver the liquid in response to alternating relative movement of the piston member axially within the cylinder member. One of these members, preferably the piston member, has a connection for engagement by a driving element such as an eccentric driven by an electric motor. The other member, preferably the cylinder member, is connected to a supporting element or chassis through a resilient connecting attachment which is prestressed to resist relative axial movement of such other member when the pumping pressures are within the desired range. The resilient attachment permits such relative axial movement, however, to a greater or lesser extent, when the pumping pressures exceed the desired range. Thus the other member moves, at times, more or less as a unit with the alternatingly driven member of the pump, to reduce or stop the pumping flow at such excessive pressures.

A preferred resilient attachment includes an outer pressure control cylinder within which the pump cylinder body is supported for limited axial movement by two axially movable annular control pistons. Controlling pressures are established by a hydraulic circuit which includes the zone between the control pistons and a pressure accumulator which controls the prestressing of the resilient attachment.

11 Claims, 4 Drawing Figures

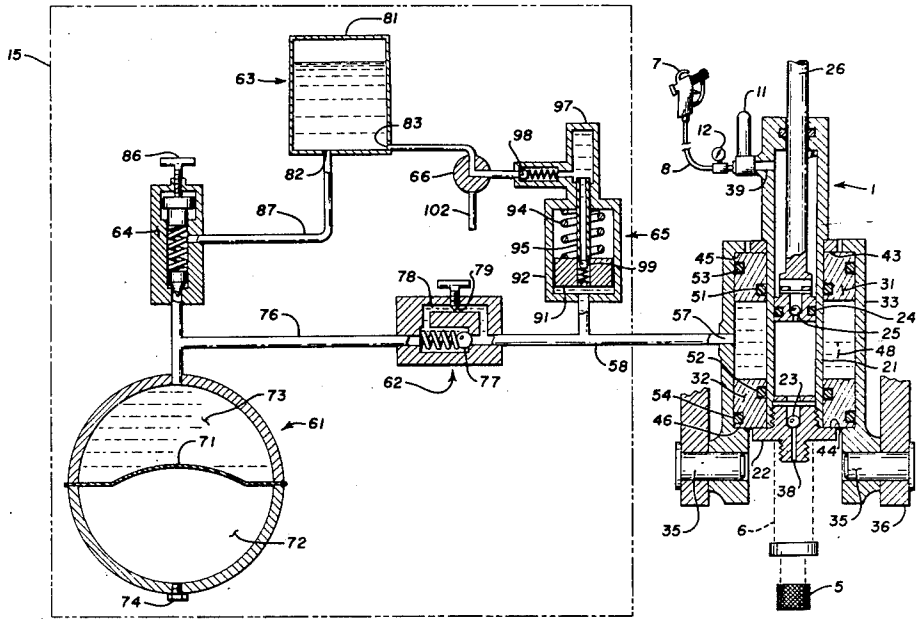


Fig. 2

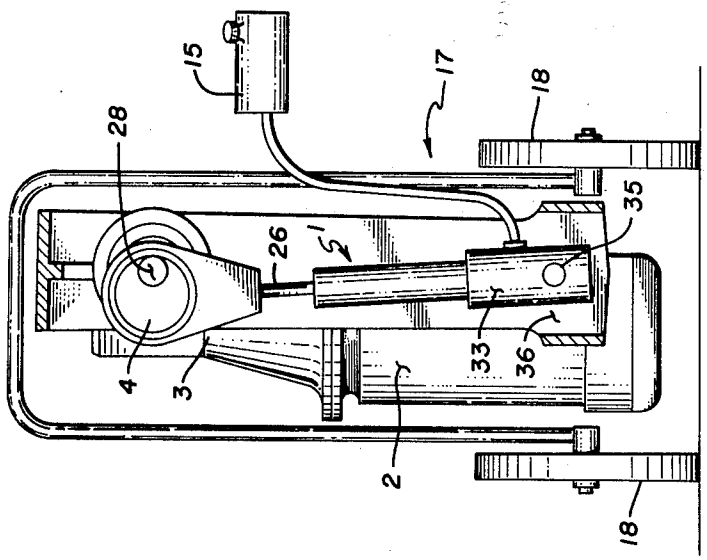


Fig. 1

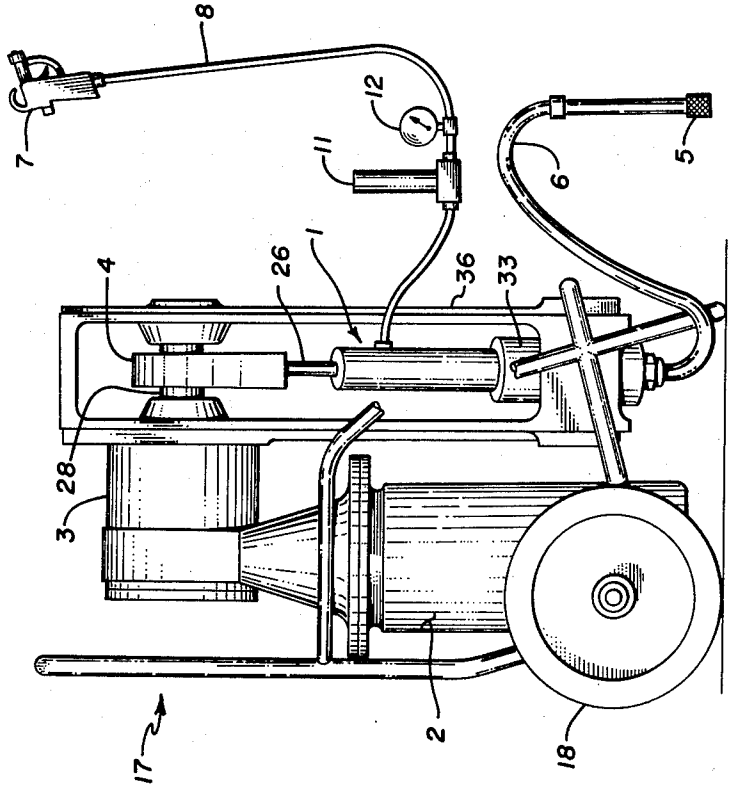


Fig. 3

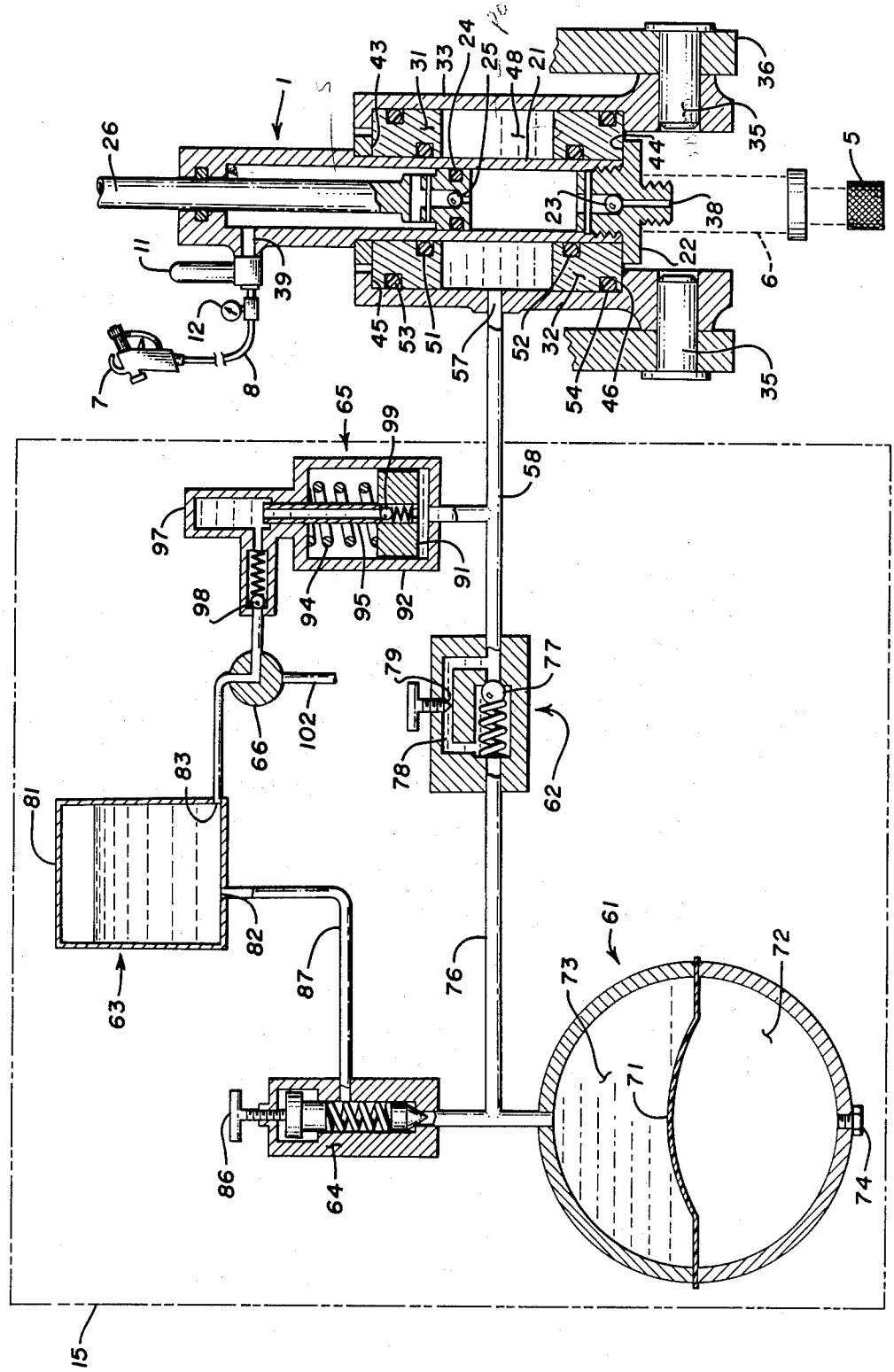
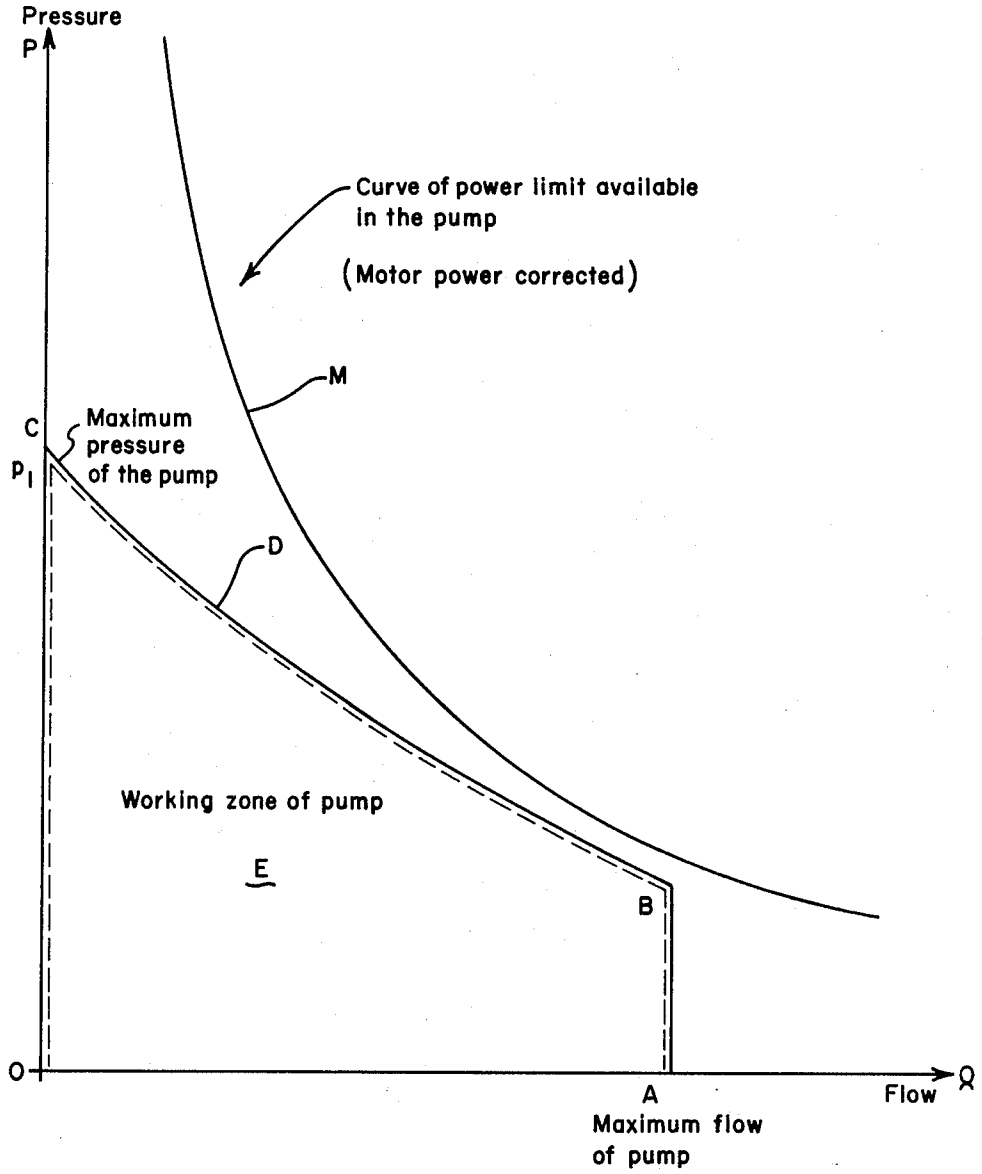

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76
77
78
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102

Fig. 4


Pressure
P
Curve of power limit available in the pump
(Motor power corrected)
M
C
Maximum pressure of the pump
P1
D
Working zone of pump
E
B
O
A
Maximum flow of pump
Flow
Q

PUMPS AND PAINTING INSTALLATIONS

BACKGROUND OF THE INVENTION

Direct pressure spraying pumps, i.e., those which are suitable for spraying liquid to a direct pressure so-called "airless" spray gun which does not require additional air to atomize the liquid must meet a variety of different conditions. These pumps must operate under different running conditions. They should be operable within a work range as wide as possible, including the possibility of obtaining high pressures at very low flow rates, as well as high flow rates at rather low pressures. Such pumps should also be adaptable as part of a light weight spray apparatus which is readily portable, and which can be used with readily available power supplies.

The desired range of running conditions can be rather easily met, when alternating stroke pneumatic motors are used to drive a paint supply pump, but the problem becomes difficult to solve when a mechanically driven pump is to be connected to an electric motor, which is necessary when the pump units are to be used in small private building yards or plants where compressed air is not readily available. In such cases it is necessary on the one hand to limit the weight of the installation in order for it to be easily carried from one place to another. This consequently reduces the permissible size of the electric motor. On the other hand, this type of use also limits the power to be used, since the electric power available in private building yards and shops is generally low enough to place resulting limits on the motor power to be used.

It is possible to meet the above-stated variety of operating conditions by using an electric motor in which the speed may be varied, but this solution is far too expensive. It is also possible to meet the different running requirements by using a pump construction in which the length of the piston stroke may be varied. However, it is not practical to vary such piston strokes by modifying the radius of the driving eccentric, because this involves too heavy a construction, which is not acceptable for a portable unit.

SUMMARY OF THE INVENTION

In order to solve these problems in an acceptable manner, the present invention provides a suction and delivery pump with piston and cylinder members which are relatively movable with respect to each other in alternating pumping strokes. One of these members has a connection for engagement and movement by an alternating driving element for the pump, such as an eccentric on a rotary shaft. Between the other member and a suitable supporting element for it, the invention provides a resilient attachment or connection which is prestressed in both directions to resist relative movement of the member. Thus, when the pumping pressures within the cylinder member are within a desired range, the resilient attachment will completely resist relative movement between the supporting element and the member which it supports, while the other member reciprocates back and forth at the normal stroke length provided by the driving eccentric.

Preferably, the arrangement is such that the piston member is positively and directly connected to the driving eccentric, whereas the cylinder member is connected to the supporting element through the resilient or elastic attachment.

In this particular arrangement, when the pumping pressures within the cylinder member exceed a desired predetermined pressure range, the prestressing of the resilient connection is overcome to permit relative movement of the cylinder member, in the preferred case, with respect to the supporting element. Thanks to this feature of construction, when the pressure in the pump reaches the level of the prestressing or constraint provided by the elastic attachment, the assembly made up of the pump body or cylinder and the pump piston can move together as a whole, thus overcoming the preconstraint of the elastic support attachment. The result is that the pump stops delivering liquid to the spray unit. The preconstraint is calibrated at a precise predetermined value, which consequently limits the pressure provided by the pump to the desired pressure range, which may also be very precise.

The preferred form of elastic attachment or connection is one in which two annular pistons can slide axially within the space between the outer surface of the pump cylinder and an inner cylindrical surface of the supporting element. Each of the surfaces has two axially spaced stops which limit the extent to which the two annular pistons can be separated from each other along either of the cylindrical surfaces. The annular space between these two annular pistons is filled with pressurized fluid in a manner which resiliently urges the annular pistons away from each other and against the stops on both the pump cylinder and supporting element, to hold the pump cylinder stationary within the supporting element when the pumping pressures are within the desired range. The pressurized fluid within the annular space between the annular pistons is provided in such a manner that the pistons can be moved toward each other to a greater or lesses extent, when the pressure within the pump cylinder exceeds that within the annular control space and tends to move the pump cylinder with the pump piston member more or less as a unit.

The preferred construction also has a connection between the annular pressure control chamber located between the annular pistons and a suitable pressure accumulator, into which the pressurized fluid within the pressure regulating chamber may be forced when the pressure within the pump cylinder is greater than that within the pressure control chamber. The invention further provides a one way flow control device and a pressure variation damping system in the connection between the accumulator and the pressure control chamber.

Some of the advantages which can be expected in the use of pumps constructed according to this invention are as follows:

a. The construction limits the power actually consumed by the pump and consequently limits the size of the motor which is necessary to drive such a pump.

b. The arrangement limits the pressure at the pump outlet, whether the spraying nozze is closed or open.

c. The device allows optimum use of the performance characteristics of the pump driving motor, by using to the best possible extent a working zone which is made possible by the particular motor power curve.

d. The construction can be easily calibrated within a wide range of pressures and delivery flow rates suitable for the material being used and for the particular appli-

cations of the material to be sprayed. In particular, for painting applications, these pressures need to be well defined in order to obtain correct spraying at the nozzle. Thus the invention also makes possible an improved painting installation, which includes a pump of the improved construction defined above.

Other features and advantages of the invention will be better understood from the following description and the attached drawings which show a direct pressure airless spraying installation as one illustration, but not a limiting example, of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings which form a part of the application, and in which like reference characters indicate like parts,

FIG. 1 is a side elevation of one form of spraying apparatus embodying the invention;

FIG. 2 is an end view of the apparatus of FIG. 1;

FIG. 3 is a schematic showing, with some parts shown in section and some with more complete details, of the apparatus of FIGS. 1 and 2; and

FIG. 4 is a graph showing characteristics of operation of the apparatus.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The direct pressure (i.e., high pressure "airless") spraying installation according to a preferred embodiment of this invention is shown generally in FIGS. 1 and 2 and includes a special pump assembly 1 driven by an electric motor 2 which has a speed reducer 3 driving an eccentric 4. The installation includes a paint strainer 5 at the end of a hose 6, for insertion in a suitable supply reservoir or container of liquid to be sprayed. The installation also includes a spray gun 7 connected with the outlet opening of the pump by a flexible hose 8, through a suitable filter 11 and pressure gauge 12. The improved pump assembly of this installation also includes a hydro-pneumatic assembly 15, shown in more detail in FIG. 3, and the whole pumping assembly is supported by a chassis or supporting frame 17 on wheels 18.

The special pump assembly 1 is an alternating stroke suction and delivery pump which includes a pump cylinder 21 (details of which are shown in FIG. 3), a bottom cylinder head 22 with a suction valve 23 therein, and a piston 24 with a delivery valve 25, the end of the piston rod 26 (sometimes called displacement rod) being coupled with eccentric 4 (FIGS. 1 and 2) on shaft 28, which consists of an extension of the output shaft of the speed reducer 3.

To provide the desired elastic or resilient connection between the pump cylinder and the suitable supporting element according to the invention, the pump cylinder may slide, with close engagement, within two axially spaced annular pistons 31 and 32 (FIG. 3). These pistons, in turn, are supported for axial sliding movement within an outer cylinder 33, thus providing an annular hydraulic control chamber 48 which is further described below. The supporting cylinder 33 serves as the axially fixed supporting element for pump cylinder 21. This cylinder 33, however, may swing on a shaft 35 (made in this case as two spaced shaft portions, one at each side of the pump cylinder axis) parallel to the shaft 28 of the pump driving eccentric 4. These shaft portions 35 are supported by a hollowed-out bed plate 36 rigidly connected or integral with chassis 17. The pump cylinder suction orifice is shown at 38, connected with inlet strainer 5 by hose 6. The outlet orifice from the pump cylinder is shown at 39 and is appropriately connected to the point spray gun 7 through hose 8, as described. Shaft portions 35 permit the cylinder to swing laterally (but not axially) to accommodate the lateral movement of piston rod 26 by eccentric 4.

The two annular or ring pistons 31, 32 of the resilient attachment, can slide axially both over the cylindrical external surface of the pump cylinder body 21 and within the internal cylindrical face of the hydraulic control chamber cylinder 33, to allow the pump body cylinder 21 to be driven axially back and forth within cylinder 33. The distance between the two ring pistons 31 and 32 is limited on the pump cylinder 21 by two shoulders 43, 44 and in the control chamber 33 by two other shoulders 45, 46. The axial distance between the two shoulders 43, 44 is equal to the axial distance between shoulders 45 and 46.

Thus the sides of the two ring pistons 31, 32 which face each other, the bore of control chamber cylinder 33, and the cylindrical outer surface of pump body cylinder 21 form a closed control space 48, which is tightly sealed by O-rings 51, 52, 53 and 54 mounted in the corresponding annular grooves in the internal and external cylindrical surfaces of these annular pistons.

This annular pressure control space 48 is connected through an opening 57 in the wall of control cylinder 33 with a pipe 58 which extends into the hydropneumatic assembly 15.

The hydro-pneumatic assembly 15 includes a pressure accumulator 61, a device 62 for controlling the flow of oil, an oil reservoir 63, a discharge valve 64 and a pump-damper device 65 connected with reservoir or tank 63 by a three-way valve cock 66.

Pressure accumulator 61 is of a spherical type and is divided by a flexible membrane 71 into two compartments 72, 73. The first compartment is fitted with an inflation valve 74 and contains compressed air, while the second compartment contains oil and is connected to the pipe 58 through the intermediate pipe 76 and the oil flow controlling device 62.

The device 62 for controlling the flow of oil includes a valve 77 which permits the free passage of the oil in pipe 58 toward the accumulator 61, the flow of oil in the opposite direction being restrained by its passage through a conduit 78 which serves as a bypass around valve 77 and is provided with a calibrated restricting orifice formed in this example by a pin-cock 79. Thus device 62 is an adjustable one-way flow restraining device.

Oil tank 63 includes an air freeing or venting orifice 81 and two lower orifices 82, 83 connected respectively with the discharge valve 64 and with a three-way valve 66. The relief or discharge pressure of the discharge valve 64 may be adjusted by means of a screw 86 in such a manner as to limit the pressure within compartment 73 of the accumulator to which the discharge valve is connected, the excess oil being returned to reservoir 63 through an outlet pipe 87 of the discharge valve.

The damping pump 65 includes a hollow piston 91 moving within a cylinder 92 which is in communication with the pipe 58 connected to the hydraulic control chamber 48 within cylinder 33. The force exerted by the oil on piston 91 is balanced on the other face of the

piston by a calibrated spring **94.** The assembly is made in such a way that when there is no pressure, the spring is not preconstrained. This system forms a damper for the variations in oil pressure within the hydraulic pressure regulating chamber **48.**

This assembly is completed by elements which permit it to play, moreover, the part of an auxiliary pump for pressurizing the circuit. For this purpose, a hollow piston **95** of smaller diameter, which is integral with the damping piston **91,** works as a ram or plunger in a second chamber **97** equipped with a suction valve **98** connected with the orifice **83** of oil reservoir **63** through the three-way valve or cock **66.** The piston **95** is itself fitted with a valve **99** for driving back the oil into the pipe **58** connected to the hydraulic compensation chamber.

On the three-way cock **66** is also connected a pipe **102** for connection with a source of oil under pressure.

The operation of the assembly of this installation is as follows:

Pump **1** is a double-acting pump. The amplitude of stroke of its piston **24** is determined by the radius of eccentric **4,** and the principle of regulation consists in reducing or annuling the relative displacement of the piston with respect to the body (cylinder member) of pump **21** by allowing the latter to partially or completely follow the movement of the piston according to the pressure within the pump.

The accumulator **61** is initially inflated through valve **74** to a starting pressure Pi. The volume of air in compartment **72** of the sphere is then equal to the total volume of the sphere.

The hydraulic circuit is then filled with oil at a pressure lower than Pi, through the suction valve **98** of the auxiliary pump **65,** the three-way cock **66** and the pipe **102.**

The annular control space **48** reaches its maximum pressure value in response to the effect of the pressure of the injected oil. Annular pistons **31, 32** are respectively in engagement with the stops **43, 45** and **44, 46.**

The whole circuit is purged with the aid of suitable devices.

A new quantity of oil is fed into the circuit under a pressure greater than Pi and penetrates into chamber **73** of the sphere, which leads to a new value Vo of the air volume in compartment **72** of the sphere. Volume Vo is selected as a function of the desired characteristics. It must be greater than the volume generated by the displacement of one of the regulating pistons **31** or **32** along a length equal to the eccentric radius.

A pressure Po common to both the enclosed air and the hydraulic circuit correspond to this new volume Vo.

The outside oil feeding system **102** is disconnected and the suction valve **98** of the auxiliary pump **65** is put into communication with the outlet **83** of oil tank **63** through the cock **66.**

In the following explanations, the main circuit will mean the assembly consisting of the control chamber **48,** the sphere **61** and the connecting tube **58, 76** which directly connect them.

The following symbols also have the meaning indicated:

S: Effective area of pistons **31, 32** in the control chamber.

Po: The pressure common to the air and the hydraulic circuit.

s: The effective area of the piston **24** in pump **1** (which is equal to the cross-sectional area of displacement rod **26**).

p: The pressure of the liquid in the pump.

The force exerted by the pressure of the circuit on the surfaces of the control pistons **31, 32** is equal to:

$$F_1 = Po\ S$$

When the pump is put in operation, the force exerted on the bottom of the pump cylinder by relative downward movement of the piston is:

$$F_2 = p\ s$$

In a first assumption, if the pressure in the pump is such that:

$$F_2 < F_1 \quad \text{or} \quad p < Po\ S/s$$

then the pump body **21** is held in its position by the annular pistons **31, 32.** The pump piston describes, relative to the pump body, a maximum travel or stroke. Thus one has the operating conditions for maximum delivery of fluid.

On the graph which shows pressures plotted against delivery or flow rates for this device (See FIG. **4**), this operation at maximum flow rate is represented by a straight line segment AB parallel to the axis of the pressures.

The two ends of the segment are:

its meeting point A with the axis of flow or discharge rate, which corresponds to a null pressure with a maximum flow or delivery; and

point B which corresponds to the pressure:

$$po = Po\ S/s$$

In a second hypothesis, the pump outlet is closed. Since this is a volumetric pump, the pressure increases at once, and the piston and the pump cylinder body can then be considered as a rigid element connected with the rod-crank system. The control pistons **31** and **32** then describe, within the control chamber, strokes equal to the radius of the eccentric. Control piston **31** reaches its maximum stroke at the lowest point of the eccentric, and piston **32** at the highest point of the eccentric.

At these points, the volume of oil generated by the displacement of the piston

$$v = S\ e \text{ (} e \text{ being the radius of the eccentric)}$$

is forced into the oil compartment **73** of the sphere **61,** thus reducing by the same proportion the air volume, whose value becomes

$$V_1 = Vo - v.$$

The air pressure is then

$$P_1 = Po\ Vo/Vo - v$$

and the pressure of the liquid in the pump is

$$P_1 = P_1\ S/s.$$

On the graph of pressures *v.* flows for the apparatus, a point C is obtained ($p = P_1$), ($Q = O$)

corresponding to operation of the unit at a O or nil flow.

In a third assumption, the pump is discharged into a system in which the pressure drops are such that the pressure p reaches a value

$$po<p<P_1$$

When pressure in the hydraulic circuit is lower than $p = p\ s/S$

the force exerted by the annular piston **31** in engagement with the stop **43** and opposing itself to the downward movement of the pump body **21** is lower than the force exerted by the piston **24** of the pump on this same pump body (this latter force results from the pressure inside of the pump body). The result is that the relative stroke of pump piston **24** with respect to the pump cylinder body **21** is temporarily annulled and is replaced by an equal stroke of the regulating piston **31** in the control chamber.

When the volume of oil forced out of the annular control space **48** of the control chamber and into the sphere **61** by means of this stroke reaches a value such that

$P = ps/S$

the force holding the control piston **31** is sufficient, the displacement of the pump body **21** disappears, and the relative movement of the pump piston **24** with reference to the pump cylinder **21** reappears, giving a new start to the flow rate.

In the course of this stage of operation, the relative stroke of the pump piston with respect to the pump body is a partial stroke, which causes a partial flow.

Curve D, which corresponds to operation of the unit at a partial flow, is a line whose ends are at points B and C.

On the graph, the zone which represents all the possible operating conditions of the pump is thus the zone E defined by the segments AB, BC and the portions OA and OC of the axes of the graph.

Finally, the curve M of the graph represents the ultimate power curve available from the pump, i.e., the power of the motor, taking into account the total output of the installation.

The one-way flow restraining device **62** has the objective of limiting the pressure in the control chamber **48** during return movement of the control pistons **31, 32** after they have passed top and bottom dead-centers of the eccentric, thus reducing to a considerable extent the effects of reversal of the direction of work on the eccentric and on the speed reducer.

The damping device **65** for pressure variations, which is located between the control chamber **48** and the one-way flow retarding device **62,** is designed for damping the shocks between the stops and control pistons **31, 32.** In effect, when one of the control pistons ends its stroke in the control chamber to return into engagement with a stop of the control chamber, the opposite stop of the pump comes to rest against the other piston. Without a damping device, the pressure in the control chamber would change bluntly from the low pressure defined by the one-way flow controlling device to the pressure within the sphere **61.** Since piston **91** of the damping system rests against the spring **94** without preconstraint, variations in volume are produced at low pressures.

By absorbing the volume of oil displaced by the starting portion of the stroke of control piston **31,** the damping system **65** delays the opening of valve **77** of the flow restraining device **62** and allows a gradual increase of pressure up to the value of the pressure in the sphere **61.**

This system is even more adaptable when the diameter of piston **91** is substantial and the spring **94** flexible.

This system also offers the advantage of incurving the operating or running curve in the same direction as the motor power curve M.

Mechanical damping devices against shock may, in addition, be advantageously located between the various stops and control pistons.

The auxiliary oil pump incorporated in assembly **65** provides for increasing the pressure of the circuit by injecting into it oil contained in the reservoir **63.** The pump is operated by movement of the damping piston **91** and then works continuously when the apparatus is running at a partial or null flow.

The adjustable discharge valve **64** serves to regulate the level of desired pressure within the circuit. Excess oil is sent back to the tank **63.**

It will be understood that the invention is not limited to the specific mode of carrying it out which is described and shown, and that many modifications may be made according to the particular applications excepted, without departing from the heart of the invention.

We claim:

1. A high pressure airless paint spraying installation including a suction and delivery pump comprising a pump piston member and a pump cylinder member within which the pump piston member defines at least one pumping chamber having inlet and outlet passages, said pump piston and pump cylinder members being relatively movable with respect to each other in alternating strokes along a predetermined axis to provide pumping pressures in the pumping chamber within a desired high pressure range, one of said pump members having a driving connection for engagement and movement of that member in opposite directions along said axis by an alternating driving element for the pump, a supporting element for normally holding the other of said pump members at a fixed position along said axis, and a resilient attachment between the supporting element and the other of said pump members, said resilient attachment being prestressed to resist relative movement of the other of said members along said axis with respect to the supporting element when the pumping pressures within the pumping chamber are within the desired range, but permitting such relative movement of the other of said members along said axis with respect to the supporting element and thereby reducing the relative axial alternating movement of the pump piston with respect to the pump cylinder when the pressures in the pumping chamber exceed the desired range, said resilient attachment including a pressure control chamber separate from said pumping chamber and a pressure control system connected to said pressure control chamber and maintaining a predetermined control pressure therein.

2. A suction and delivery pump particularly useful for high pressure spray installations which do not require additional air, said pump comprising a pump piston member and a pump cylinder member within which the pump piston member defines at least one pumping chamber having inlet and outlet passages, said pump piston and pump cylinder members being relatively movable with respect to each other in alternating

strokes along a predetermined axis to provide pumping pressures in the pumping chamber within a desired high pressure range, one of said pump members having a driving connection for engagement and movement of that member in opposite directions along said axis by an alternating driving element for the pump, a supporting element for normally holding the other of said pump members at a fixed position along said axis, and a resilient attachment between the supporting element and the other of said pump members, said resilient attachment being prestressed to resist relative movement of the other of said members in each direction along said aixs with respect to the supporting element when the pumping pressures within the pumping chamber are within the desired range, but permitting such relative movement of the other of said members in each opposite direction along said axis with respect to the supporting element and thereby reducing the relative axial alternating movement of the pump piston with respect to the pump cylinder when the pressures in the pumping chamber exceed the desired range.

3. A suction and delivery pump particularly useful for high pressure spray installations which do not require additional air, said pump comprising a pump piston member and a pump cylinder member within which the pump piston member defines at least one pumping chamber having inlet and outlet passages, said pump piston and pump cylinder members being relatively movable with respect to each other in alternating strokes along a predetermined axis to provide pumping pressures in the pumping chamber within a desired high pressure range, one of said pump members having a driving connection for engagement and movement of that member in opposite directions along said axis by an alternating driving element for the pump, a supporting element for normally holding the other of said pump members at a fixed position along said axis, and a resilient attachment between the supporting element and the other of said pump members, said resilient attachment being prestressed to resist relative movement of the other of said members along said axis with respect to the supporting element when the pumping pressures within the pumping chamber are within the desired range, but permitting such relative movement of the other of said members along said axis with respect to the supporting element and thereby reducing the relative axial alternating movement of the pump piston with respect to the pump cylinder when the pressures in the pumping chamber exceed the desired range, the resilient attachment including two annular pistons supported to slide axially in close engagement between two cylindrical co-axial surfaces, one of which is associated as part of the supporting element and the other of which is associated as part of that pump member which is connected to the supporting element, limiting stops with each cylindrical surface to limit the relative axial movement of the annular pistons, the annular pistons and cylindrical surfaces defining an annular pressure control chamber separate from said pumping chamber, and a pressure control system connected to said pressure control chamber and maintaining a predetermined control pressure therein.

4. A pump according to claim **2** in which one of the two coaxial cylindrical surfaces is an external cylindrical surface of the pump cylinder member, and the other coaxial cylindrical surface is an internal cylindrical surface of the supporting element, which thereby provides at least part of a housing for the control chamber.

5. A pump according to claim **4** having a main frame, a motor-driven rotary driving shaft with an eccentric thereon, the piston member having a rod connected to the eccentric, and the supporting element being pivotally supported on the main frame for swivelling movement on an axis parallel to the rotary driving shaft.

6. A pump according to claim **3** in which the pressurized fluid is a liquid, and the pressure control system includes a pressure accumulator having a movable partition dividing the accumulator into a pressurized gas compartment and a pressurized liquid compartment, and a connecting fluid conduit between the control chamber and pressurized liquid compartment.

7. A pump according to claim **6** in which the connecting conduit between the control chamber and pressure accumulator includes a flow controlling device having a one-way valve portion to permit free liquid flow from the control chamber to the accumulator and having a restricted return passage shunted around the valve for limiting the liquid flow in the opposite direction.

8. A pump according to claim **7**, which also includes a pressure vairation damping device having a damping chamber connected to the control chamber, and a spring-loaded damping piston movable in the damping chamber against its spring-loading in response to pressure increases in the control chamber.

9. A pump according to claim **8** in which the damping device includes an auxiliary pump chamber, a pumping piston portion moving integrally with the damping piston, a conduit having a discharge valve between the auxiliary pump chamber and damping chamber, an inlet suction valve in the auxiliary pump chamber, a reservoir for hydraulic liquid, and a connecting conduit between the auxiliary pump chamber inlet valve and the reservoir.

10. A pump according to claim **9** in which the pressurized liquid compartment of the pressure accumulator has an adjustably calibrated relief valve with an outlet orifice connected to the reservoir.

11. A pump according to claim **9** in which the connecting conduit between the auxiliary pump chamber inlet valve and the reservoir includes a three-way valve member for selective connection of the auxiliary pump chamber to a supply of liquid under pressure.

* * * * *