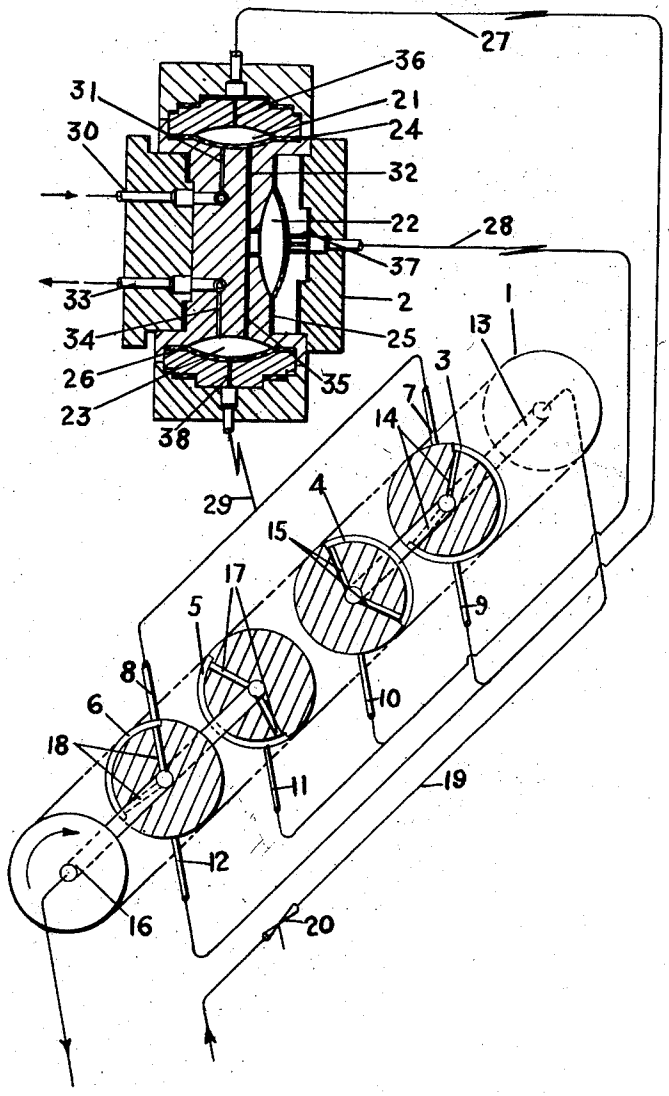
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DIAPHRAGM OPERATED DELIVERY PUMPS

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DIAPHRAGM OPERATED DELIVERY PUMPS

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The present invention relates to improvements in or relating to diaphragm operated delivery pumps.

The object of the invention is to provide a diaphragm operated delivery pump and particularly a diaphragm operated metering pump in which its diaphragm portion has preferably a low working volume, is free from relative movement between metallic parts, and in which the internal pressure cannot exceed a predetermined maximum pressure thereby making the pump particularly useful for the delivery of liquids sensitive to detonation as for example liquid explosive nitric esters.

According to the present invention a diaphragm operated delivery pump for liquids is provided having a diaphragm portion which separates the liquid collecting chamber from the gas collecting chamber. This portion is actuated to discharge liquid from the liquid collecting chamber through an exit valve as gas is supplied to the gas collecting chamber. Preferably, the pump includes a valve controlled, gas distribution valve to permit delivery of an intermittent supply of gas at a pressure above that at which liquid is being introduced into the liquid collecting chamber and below a predetermined maximum pressure. This gas distribution valve is so constructed as to permit escape of gas from the gas collecting chamber after the discharge of the liquid and so to permit entry through a non-return inlet valve of a fresh supply of liquid. Moreover, the gas distribution valve is in separate communication with said exit valve and is so constructed that it closes said exit valve when liquid is delivered into the liquid collecting chamber and opens said exit valve when gas is delivered into the gas collecting chamber.

In a diaphragm operated metering pump according to the invention said gas distribution valve is in separate gas communication with said inlet valve and is so constructed that it opens said inlet valve after the discharge of liquid from the liquid collecting chamber and closes said inlet valve when gas is delivered into the gas collecting chamber.

Furthermore the said exit valve is preferably diaphragm operated and said inlet valve is also preferably diaphragm operated.

The gas distribution valve can be rotatable and the delivery from a pump of the invention can be varied as required by altering the speed of rotation of the gas distribution valve. On the other hand the gas distribution valve may be of the kind comprising a series of gas control valves for example each electrically operable and operated in sequence by for example an electrically operated controller.

Greater deliveries may be obtained by using a larger pump but it is preferable to keep the liquid collecting chamber capacity small and to use several pumps in parallel connection or to use a multi-liquid collecting chamber pump. When it is desired to deliver liquid through a very long delivery pipe additional pumps of the type described may be used in series connection as booster pumps. Here if a metered supply is required it is desirable to run all the pumps at the same speed and to make the booster pump liquid collecting chambers a little greater than the corresponding chamber in the control or metering pump. Under these conditions the larger pumps

run at reduced efficiency and the small pump has complete control of the delivery rate. When such long pipes are used between each pair of a series of such pumps, the pumps may all be run at the same gas pressure, as the lower liquid pressure required at the inlet valves is achieved by reason of the pressure drop along the pipes.

The said multi-liquid collecting chamber pumps if desired can be connected together in series or in parallel.

One embodiment of a diaphragm operated delivery pump according to the invention in the form of a metering pump is illustrated partly in cross-section and partly schematically in the diagrammatic drawing accompanying the specification.

Referring to the drawing 1 is a gas distribution valve shown schematically which can rotate in a closely fitting housing (not shown) and is connected to the diaphragm portion 2 shown in vertical cross-section. The gas distribution valve 1 comprises a rotatable cylinder one half of which is so constructed as to permit the distribution of gas pressure and the other half is so constructed as to permit the release of gas pressure to the atmosphere. The half which permits distribution of gas pressure is provided with part circumferential grooves 3 and 4 and the other half which permits release of gas pressure is provided with part circumferential grooves 5 and 6. The close fit of the housing round the rotatable cylinder in effect converts these circumferential grooves 3, 4, 5 and 6 into ducts positioned and rotating within the housing. The housing has six ducts 7, 8, 9, 10, 11 and 12. During a portion of the revolution of the distribution valve 1 groove 3 communicates with duct 7 and during another portion of its rotation with duct 9 and in one stage of rotation ducts 7 and 9 are in communication with each other through groove 3, but this is of no significance. Similarly groove 4 communicates with duct 10, groove 5 with duct 11 and groove 6 with duct 8 or duct 12. Ducts 8 and 12 are never in communication with each other through groove 6, and axial duct 13 is always in communication with groove 3 through ducts 14 and with groove 4 through ducts 15. Another axial duct 16 is always in communication with groove 5 through ducts 17 and with groove 6 through ducts 18. The axial duct 13 can be connected to a supply for a gas, preferably air, through a pipe 19 by way of a reducing valve 20 which controls the gas pressure to be delivered to the gas distribution valve 1 to a pressure less than a predetermined maximum pressure which is to be greater than the pressure which is to be applied to the liquid to be introduced into the diaphragm portion 2. Axial duct 16 is open to the atmosphere.

The diaphragm portion 2 contains cavities 21, 22 and 23. Cavity 21 has a diaphragm 24. Cavity 22 has a diaphragm 25 and cavity 23 has a diaphragm 26. Cavity 21 is connected by pipe 27 to ducts 9 and 12, cavity 22 is connected by pipe 28 to ducts 10 and 11 and cavity 23 is connected by pipe 29 to ducts 7 and 8.

Liquid inlet 30 communicates with cavity 22 through ducts 31 and 32 except when diphragm 24 in cavity 21 seals ducts 31 and 32. Similarly the liquid outlet 33 communicates with cavity 22 through ducts 34 and 35 except when diaphragm 26 in cavity 23 seals off ducts 34 and 35. Ducts 32 and 35 are at all times in communication. 36, 37 and 38 are surge preventing ducts.

The capacity of the liquid collecting chamber 22 is 6 ml. and the capacity of each of the valve chambers 21 and 23 is 1.5 ml. The speed of rotation of the gas distribution valve 1 can be varied as desired. A convenient rotational speed is 30 revolutions per minute.

The metering pump as illustrated shows it in a position about to commence the discharge of liquid. It is assumed

throughout the following description that the liquid at the outlet 33 is subjected to a back pressure due to the deliberate inclusion of small bore tubing in the path of the discharge liquid in accordance with the process claimed inter alia in my co-pending application Serial No. 373,493. Should such a back pressure be absent the metering pump behaves just as accurately but the action of the diaphragm portion 2 in any one revolution of the gas distribution valve 1 is slightly different to the one to be described.

As duct 9 is in communication with groove 3 and so with the air supply and since duct 12 is sealed air pressure is applied to diaphragm 24 sealing off ducts 31 and 32. Ducts 10 and 7 are sealed off from the air supply and ducts 11 and 8 are open to the atmosphere through grooves 5 and 6 and therefore there is no air pressure on diphragms 25 and 26. The liquid collecting chamber 22 is full of liquid and the outlet valve diaphragm 26 is in position to permit communication between ducts 35 and 34. After the gas distribution valve 1 has rotated slightly, duct 11 is sealed off and then duct 10 is brought into communication with groove 4. Air pressure is thus applied to diaphragm 25 which moves so as to force the liquid from chamber 22 through ducts 35 and 34 to the outlet 33. Further rotation of the gas distribution valve 1 leads to the opening of duct 7 to air pressure and the sealing of duct 8 and thus to the application of air pressure to diaphragm 26 causing this diaphragm 26 to move so as to force liquid from outlet valve chamber 23 through duct 34 to the liquid outlet 33 and then to seal duct 35 from duct 34. On further rotation of the gas distribution valve 1 duct 9 is sealed off and duct 12 is opened to the atmosphere thereby permitting liquid under pressure to move from liquid inlet 30 through duct 31 to move diaphragm 24 to fill inlet valve chamber 21 and to communicate with duct 32. As soon as duct 10 is sealed off and duct 11 opened to the atmosphere this liquid pressure enables liquid to flow through the inlet valve chamber 21 through duct 32 to fill the liquid collecting chamber 22 thereby moving diaphragm 25 to the position shown in the diagrammatic drawing. Further rotation of the gas distribution valve 1 seals duct 12 and so permits gas pressure through duct 9 and pipe 27 to actuate diaphragm 24 and to force liquid from inlet valve chamber 21 through the duct 31, back into the liquid inlet 30 and then to seal duct 32 from duct 31. In a further stage of rotation of the gas distribution valve 1 this valve is again in a position shown in the drawing when there is a release of pressure from diaphragm 26. Liquid from the outlet 33 is subjected to a back pressure moves through duct 34 to fill outlet valve chamber 23 moving diaphragm 26 to the position shown in the drawing and bringing duct 35 into communication with duct 34. A complete cycle has thus been performed and the net or algebraic total volume of liquid discharged in this one cycle through the outlet 33 is the volume of the liquid collecting chamber 22.

To avoid lubricating the contact faces between the rotatable gas distribution valve 1 and its housing there is a clearance of two thousandths of an inch between these faces, and so to prevent leakage between grooves 3, 4, 5 and 6, circumferential grooves (not shown) open to the atmosphere are provided between said grooves 3 and 4, 4 and 5, and 5 and 6.

Should any one of the diaphragms 24, 25 or 26 burst, the pump will cease to deliver liquid and liquid will not reach the gas distribtuion valve 1 through pipes 27, 28 or 29.

What I claim is:

1. In a delivery pump for liquid such as nitroglycerin and the like, the combination comprising: a pump diaphragm; means defining a pump liquid chamber on one side of said diaphragm and a pump gas chamber on the other side of said diaphragm; a non-return inlet valve connected with said pump liquid chamber through which the liquid to be pumped is supplied under pressure; an exit valve having an exit valve diaphragm and means defining an exit valve liquid chamber on one side of said valve diaphragm and an exit valve gas chamber on the other side of said valve diaphragm; means connecting said pump liquid chamber with said exit valve liquid chamber; said connecting means defining narrow ducts for preventing surges of liquid passing between said liquid chambers; gas distributing valve means movable into different positions to control the distribution of a gas under pressure to and from said gas chambers; and means connecting said gas distributing valve means to said gas chambers for exhausting the pump gas chamber to atmosphere through said gas distributing valve means and supplying gas under pressure to said exit valve gas chamber through said gas distributing valve means in one position of the latter to thereby permit liquid under pressure to enter said pump liquid chamber through said inlet valve, and for supplying gas under pressure to said pump gas chamber through said gas distributing valve means and exhausting said exit valve gas chamber to atmosphere through said gas distributing valve means in another position of the latter to thereby force the liquid from said pump liquid chamber outwardly through said exit valve liquid chamber; said means connecting said distributing valve means to said gas chambers defining narrow ducts communicating with said gas chambers for preventing surges in the gas passing between said gas chambers and said gas distributing valve means.

2. The combination as defined in claim 1 wherein means is provided for limiting the maximum gas pressure supplied through said gas distributing valve means.

3. In a diaphragm operated delivery pump for liquid such as nitroglycerin and the like, the combination comprising: an inlet valve diaphragm; a pump diaphragm; an exit valve diaphragm; means defining a liquid chamber on one side of each of said diaphragms, a gas chamber on the other side of each of said diaphragms, and narrow ducts interconnecting the liquid chamber of each of said diaphragms for preventing surges in the liquid passing therebetween; gas distributing valve means movable into different positions to control the distribution of a gas under pressure to and from the gas chambers of each of said diaphragms; and means connecting said gas distributing valve means to said gas chambers for exhausting the inlet valve gas chamber and pump gas chamber to atmosphere through said gas distributing valve means and supplying gas under pressure to said exit valve gas chamber through said gas distributing valve means in one position of the latter to thereby permit liquid under pressure to enter said pump liquid chamber through said inlet valve liquid chamber, for supplying gas under pressure to said inlet valve gas chamber through said gas distributing valve means in a second position of the latter to thereby trap the liquid contained within the pump liquid chamber, for exhausting the gas within the exit valve gas chamber through said gas distributing valve means in a third position of the latter to thereby permit the liquid contained within the pump liquid chamber to pass outwardly through said exit valve liquid chamber, and for supplying gas under pressure to said pump gas chamber through said gas distributing valve means in a fourth position of the latter to thereby force the liquid from said pump liquid chamber outwardly through said exit valve liquid chamber; said means connecting said distributing valve means to said gas chambers defining narrow ducts communicating with said gas chambers for preventing surges in the gas passing between said gas chambers and said gas distributing valve means.

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