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Displacement pump with fluid reservoir

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The present invention concerns a displacement pump having a delivery chamber connected to a pressure and a suction connection. The displacement pump further has a displacer element which determines the volume of the delivery chamber and which can be reciprocated between a first position in which the delivery chamber is of a smaller volume and a second position in which the delivery chamber is of a larger volume. Usually the pressure connection is connected to the delivery chamber by way of a pressure valve in the form of a non-return valve and the suction connection is connected to the delivery chamber by way of a suction valve which is also in the form of a non-return valve.

To deliver a medium the displacer element which for example can be a diaphragm is reciprocated oscillatingly between the first and second positions. In the movement of the displacer element from the first position into the second position, the so-called suction stroke movement, the volume of the delivery chamber is increased whereby the pressure in the delivery chamber drops. As soon as the pressure in the delivery chamber falls below the pressure in a suction line connected to the suction connection the suction valve opens and medium to be delivered is sucked into the delivery chamber by way of the suction connection. As soon as the displacer element moves from the second position in the direction of the first position again (this is the so-called pressure stroke movement) the volume in the delivery chamber decreases and the pressure in the delivery chamber rises. The suction valve is closed to prevent a backflow of the medium to be delivered, into the suction line. As soon as the pressure in the delivery chamber exceeds the pressure in a pressure line connected to the pressure connection the pressure valve is opened so that the delivery medium in the delivery chamber can be pushed into the pressure line.

Such a displacement pump which is in the form of a diaphragm pump is described and illustrated in EP 1 546 557 B1.

When metering liquids, in particular outgassing delivery media like for example sodium hypochlorite (NaOCl) gas bubbles can be formed in the suction line which is connected to the suction connection, and sucked into the metering head. It is also possible for gas bubbles to be formed in the delivery chamber. That is frequently the case after prolonged breaks in the metering process. As the suction connection is connected to a suction line which in the simplest case is in the form of a hose and ends in a supply container it can happen when changing the supply container, in particular with the pump running, that the suction line is briefly no longer connected to the delivery medium and sucks in gas.

If there is too much gas in the metering head of an oscillating delivery pump disturbances in the metering operation can occur if the inherent compressibility of the metering head is no longer sufficient, by virtue of the included gas volume, to open the pressure valve against the non-return spring, the inherent weight of the closing member and the system pressure. In other words it can happen that, if the proportion of gas in the delivery chamber is too high, in spite of the movement of the displacer element from the second position into the first position, the pressure in the delivery chamber does not increase sufficiently to open the pressure valve connected to the pressure connection. The cause of this is the compressibility of gas, which is high in comparison with liquids.

If therefore the displacer element no longer succeeds in applying a sufficiently high pressure to open the pressure valve the delivery medium is not pumped, that is to say the desired metering operation cannot take place.

To be able to get out of that fault condition it is necessary to restore the compressibility to the counteracting pressure applied at the pressure connection. That can be effected by a procedure whereby once again some liquid is introduced into the delivery chamber to improve the ratio of compressible to incompressible media in such a way that the pressure built

in the movement of the delivery element can regain the counteracting pressure at the pressure connection.

Therefore in the case of the delivery pump shown in EP 1 546 557 B1 there is provided an additional connection between the delivery chamber on the one hand and the pressure connection on the other hand, which is
5 intermittently opened to permit liquid to pass from the pressure line into the delivery chamber again, whereby at the same time gas can escape from the delivery chamber so that the ratio between compressible gases and incompressible liquids is improved again and in the ideal case the
10 counteracting pressure at the pressure connection can be restored in the delivery chamber.

That solution however is relatively complicated and expensive as besides an additional bypass line, a valve for closing same as well as an actuating device for actuating the valve have to be provided.

15 It has therefore already been proposed in WO 2013/135681 that the pressure valve is of a non-tight structure so that even when the pressure valve is closed a return flow passage interconnects the delivery chamber and the pressure connection, through which medium can pass into the delivery chamber and/or gas can escape from the delivery chamber.

20 That structure however suffers from the disadvantage that the delivery characteristic depends on the pressure in the pressure line connected to the pressure connection. Particularly if pumping is to be effected against a very high pressure the amount of delivery fluid which flows back into the delivery chamber through the non-tight pressure valve
25 markedly increases so that the metering efficiency is reduced.

With that background of the described state of the art in mind therefore the object of the present invention is to provide a displacement pump which is self-venting, which is of a simple structure and which in addition has a pressure-stable metering capacity even when there are high
30 counteracting pressures in the pressure line.

According to the invention that object is attained in that a reservoir which can be filled with delivery fluid is connected to the delivery chamber by way of a gas venting valve.

In this respect the term reservoir is used to denote any cavity which can be filled with delivery fluid and which is possibly separated by way of valves both from the delivery chamber and also from the pressure and suction connections.

5 In that arrangement the gas venting valve is so designed that it can be opened or opens automatically during the suction stroke movement at least whenever there is too much gas in the delivery chamber whereby delivery fluid is transferred from the reservoir into the delivery chamber and consequently the pressure in the delivery chamber rises further during
10 the next pressure stroke movement.

 If the rise in pressure in the delivery chamber should even then still not suffice to open the pressure valve then during the next suction stroke movement delivery fluid can again be passed from the reservoir into the delivery chamber so that the pressure in the delivery chamber rises further
15 during the pressure stroke movement. That can be continued until pressure sufficiently builds up again in the delivery chamber to open the pressure valve so that the delivery fluid, possibly together with gaseous constituents, is pumped into the pressure line.

 Therefore the displacement pump is preferably of such a design
20 configuration that delivery fluid can be transported from the suction connection by way of the suction valve into the delivery chamber without flowing through the reservoir. It is then possible during the suction stroke movement to pass liquid to be delivered into the delivery chamber even when the pressure drop is not sufficient to open the suction valve.

25 In a preferred embodiment the gas venting valve in the direction from the reservoir to the delivery chamber has a through-flow coefficient which is less than the through-flow coefficient of the suction valve. For example the through-flow coefficient of the gas venting valve can be less than 1%, or preferably even less than 0.2%, of the through-flow coefficient
30 of the suction valve. The through-flow coefficient is a measurement in respect of the achievable throughput of the delivery fluid for the valve in question and in principle is also a measurement in respect of the effective cross-section. In accordance with the present invention the absolute value

of the through-flow coefficient is not an important consideration, but only the ratio of the through-flow coefficient of the gas venting valve to that of the suction or pressure valve. Alternatively in relation thereto therefore the effective cross-section of the gas venting valve is less than 1% and preferably even less than 0.2% of the effective cross-section of the suction valve.

For example the delivery fluid through-flow of the valve (ml/min) can be defined as the definition of the through-flow coefficient, at a pressure difference of 1 bar and at a delivery fluid temperature of 25°C. The through-flow is in that case respectively defined with the valve opened.

By the corresponding reduction in the through-flow coefficient of the gas venting valve same can be opened even when there is no gas in the delivery chamber so that detection of the amount of gas is not absolutely necessary. Whenever the gas venting valve is opened a quantity of delivery fluid flows out of the reservoir into the delivery chamber, and that leads to venting of gas from the delivery chamber. It will be noted however that as a result delivery fluid is also taken from the reservoir so that the reservoir has to be filled up again. In addition this reduces the delivery capacity as less fluid is sucked in by way of the suction connection and pumped into the pressure line by way of the pressure connection. The pressure capacity however is only minimally reduced due to the great reduction in the through-flow coefficient. Particularly when the through-flow coefficient is less than 0.2% of that of the suction valve the gas venting valve can also always be opened or can comprise a suitably sized throttle.

In a further preferred embodiment the gas venting valve is in the form of a throttle non-return valve which provides a permanent throttled communication and if the pressure in the delivery chamber is greater than the pressure in the reservoir an unthrottled communication. That measure provides that the reservoir can also be filled with delivery fluid again when the delivery chamber is vented as then a part of the delivery fluid is pumped into the reservoir.

In a preferred embodiment in the unthrottled condition the throttle non-return valve has a through-flow coefficient which is less than the through-flow coefficient of the pressure valve, wherein preferably the through-flow coefficient of the unthrottled gas venting valve is less than
5 15%, particularly preferably less than 5%, of the through-flow coefficient of the pressure valve.

That measure ensures that only a small part of the delivery fluid in the delivery chamber is pumped into the reservoir and the greater proportion of the delivery fluid is transported into the pressure line.

10 In a further preferred embodiment it is provided that the gas venting valve is a non-return valve which opens when the pressure in the delivery chamber is less than the pressure in the reservoir. Particularly when the displacement pump is used in a metering installation which provides only a low pressure, for example ambient pressure, at the suction line, the
15 embodiment with a non-return valve is advantageous if the pressure in the reservoir is greater than the pressure in the suction line as then during the suction stroke movement fluid can be taken from the reservoir, even if the pressure in the delivery chamber does not drop below the pressure in the suction line.

20 In a further particularly preferred embodiment the reservoir is connected to the pressure connection. In that case it is particularly preferred for the gas venting valve to be connected in series with the pressure valve, with the gas venting valve being arranged closer to the delivery chamber.

25 In other words, delivery fluid which is pumped from the delivery chamber into the pressure line must flow firstly through the gas venting valve and thereafter the pressure valve. The reservoir is then formed by the connecting line between the gas venting valve on the one hand and the pressure valve on the other hand. It is precisely this embodiment that has
30 the advantage that the reservoir is automatically filled up again, which in the case of a separate reservoir has to be manually effected now and then. With this embodiment the through-flow coefficient of the gas venting valve

from the delivery chamber into the reservoir should approximately coincide with the through-flow coefficient of the pressure valve.

In a further preferred embodiment the reservoir is connected to an accumulator. An accumulator or also a hydraulic storage means stores the liquid, that is to say the delivery fluid, under pressure.

By way of example such an accumulator can be formed by a pressure vessel whose internal space is subdivided into two chambers by a moveable separating member, wherein a gas which serves as a pressure storage means is kept in the one chamber and the delivery fluid in the other chamber.

According to the invention the displacement pump can be used in a metering installation having a pressure line in which delivery fluid is contained at a pressure p_2 and a suction line in which delivery fluid is contained at a pressure $p_1 < p_2$, wherein the pressure line is connected to the pressure connection and the suction line to the suction connection.

Particularly preferably the delivery fluid in the reservoir is under a pressure p_3 , wherein $p_1 < p_3 < p_2$.

This embodiment has the advantage that, when there is too much gas in the delivery chamber and therefore no delivery medium is pumped by way of the pressure valve into the pressure line and even at the end of the suction stroke movement no further delivery fluid is sucked by way of the suction line and the suction valve into the delivery chamber, instead of that during the suction stroke movement delivery fluid is introduced from the reservoir into the delivery chamber by way of the gas venting valve, with the consequence that the pressure in the delivery chamber rises in the next pressure stroke movement.

Further advantages, features and possible uses of the present invention will be apparent from the description hereinafter of a preferred embodiment.

In the drawing:

Figure 1 shows a diagrammatic view of a preferred embodiment.

Figure 1 diagrammatically shows a metering installation having a displacement pump. The metering installation serves to pump a delivery

fluid from a suction line 1 in which delivery fluid is contained at the fluid pressure p_1 into a pressure line 6 in which delivery fluid is under a fluid pressure p_2 , wherein $p_2 > p_1$.

The displacement pump has a delivery chamber 3 in which a
5 displacer element 11 in the form of a diaphragm can be reciprocated
between two positions, wherein the delivery chamber is of a smaller volume
in the first position which is shown in broken line in the Figure and
identified by reference 4', and the delivery chamber is of a larger volume in
the second position which is shown in solid line and is denoted by reference
10 4.

When the diaphragm moves from the position 4' into the position 4
the volume of the delivery chamber 3 thus increases and the pressure in
the delivery chamber drops. As soon as the pressure in the delivery
chamber is less than the pressure p_1 in the suction line 1 the suction valve
15 2 which is arranged between the suction line 1 and the delivery chamber 3
and which is in the form of a non-return valve opens.

As a result delivery fluid is transported from the suction line 1 into
the delivery chamber 3.

As soon as the movement of the diaphragm is reversed, that is to
20 say as soon as the diaphragm moves from the position 4 in the direction of
the position 4' the volume of the delivery chamber 3 decreases and the
suction valve 2 is closed.

The pressure in the delivery chamber 3 further rises until the
pressure p_2 in the pressure line 6 is reached or exceeded. In that case the
25 pressure valve 5 opens and delivery fluid is transported from the delivery
chamber 3 into the pressure line 6.

Now, according to the invention, provided between the delivery
chamber 3 and the pressure valve 5 which is also in the form of a non-
return valve are a reservoir 10 and a gas venting valve 7. The reservoir 10
30 is formed by the communicating line between the gas venting valve 7 and
the pressure valve 5. The gas venting valve 7 is in the form of a throttle
non-return valve, that is to say it comprises a throttled connection 9 and a
non-return valve 8.

In normal operation, that is to say if there is no or little gas in the delivery chamber 3, the gas venting valve 7 does not influence the mode of operation of the displacement pump. The advantages of the arrangement according to the invention of the reservoir and the gas venting valve only
5 become apparent when the delivery chamber 3 contains an excessively large proportion of gaseous constituents, which can happen in operation or after a prolonged stoppage. By virtue of the comparatively high compressibility of the gaseous constituents, more specifically under some circumstances this has the result that the movement of the diaphragm from
10 the position 4 into the position 4' is no longer sufficient to increase the pressure in the delivery chamber 3 to such an extent that the pressure p_2 is reached and the non-return valve 5 can be opened. Admittedly, in this condition, the diaphragm is reciprocated between the positions 4 and 4', but there is neither opening of the suction valve 2 nor opening of the
15 pressure valve 5.

In this situation however according to the invention a small amount of the delivery fluid contained in the reservoir 10 is passed back into the delivery chamber 3 by way of the throttle 9. As a result the pressure in the delivery chamber 3 will successively rise at the end of the pressure stroke
20 movement, that is to say when the diaphragm is in the position 4', until the non-return valve 8 opens and compressed gas is passed into the reservoir 10. In the return movement of the diaphragm into the position 4 the non-return valve 8 closes and the compressed gas in the reservoir 10 can expand only to a slight degree by way of the throttle 9.

25 As the reservoir 10 now contains the gas in a compressed condition the pressure in the conveyor chamber 3 will fall during the suction stroke movement to such a degree that further delivery fluid is sucked out of the suction line 1 by way of the suction valve 2. This also leads to an increase in the pressure in the delivery chamber 3 at the end of the pressure stroke
30 movement as now there is more delivery fluid in the delivery chamber 3.

If the pressure and suction stroke movement is repeatedly performed then the pressure in the delivery chamber 3 will increase until

the gas can be compressed to such an extent that it succeeds in opening the pressure valve 5 and urging the gas into the pressure line.

In principle the gas venting valve 7 can be of precisely the same structure as described in WO 2013/135681 A1, that is to say it can have a
5 valve member and a valve seat, between which even in the closed position there is a return flow passage formed for example by a groove. Basically the gas venting valve represents a non-tight non-return valve. The described structure has the advantage that even when operating against a
10 high pressure in the suction line 6 the metering capacity does not decrease as the pressure line 6 is not permanently in contact with the gas venting valve 7. That is also advantageous from considerations relating to safety technology as, in the case of a diaphragm rupture, there is not a permanent connection between the metering line 6 on the one hand and delivery chamber 3 on the other hand.

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CLAIMS

1. A displacement pump comprising a delivery chamber connected to
5 a pressure and a suction connection, a displacer element which determines
the volume of the delivery chamber and which can be reciprocated between
a first position in which the delivery chamber is of a smaller volume and a
second position in which the delivery chamber is of a larger volume,
wherein the pressure connection is connected to the delivery chamber by
10 way of a pressure valve and the suction connection is connected to the
delivery chamber by way of a suction valve, characterised in that a
reservoir which can be filled with delivery fluid is connected to the delivery
chamber by way of a gas venting valve.
- 15 2. A displacement pump as set forth in claim 1 characterised in that
the gas venting valve is so adapted that during the suction stroke
movement it can be opened or opens automatically if the pressure in the
delivery chamber is less than the pressure in the reservoir.
- 20 3. A displacement pump as set forth in claim 1 or claim 2
characterised in that the displacement pump is so adapted that delivery
fluid can be transported from the suction connection into the delivery
chamber by way of the suction valve without flowing through the reservoir.
- 25 4. A displacement pump as set forth in one of claims 1 through 3
characterised in that the gas venting valve in the direction from the
reservoir to the delivery chamber has a through-flow coefficient which is
less than the through-flow coefficient of the suction valve, wherein
preferably the through-flow coefficient of the gas venting valve is less than
30 1%, particularly preferably less than 0.2%, of the through-flow coefficient
of the suction valve.

5 5. A displacement pump as set forth in one of claims 1 through 4 characterised in that the gas venting valve is a throttle non-return valve which provides a permanent throttled communication and if the pressure in the delivery chamber is greater than the pressure in the reservoir an unthrottled communication.

10 6. A displacement pump as set forth in claim 5 characterised in that in the unthrottled condition the throttle non-return valve has a through-flow coefficient which is less than the through-flow coefficient of the pressure valve, wherein preferably the through-flow coefficient of the unthrottled gas venting valve is less than 15%, particularly preferably less than 5%, of the through-flow coefficient of the pressure valve.

15 7. A displacement pump as set forth in one of claims 1 through 6 characterised in that the gas venting valve is a non-return valve which opens when the pressure in the delivery chamber is less than the pressure in the reservoir.

20 8. A displacement pump as set forth in one of claims 1 through 7 characterised in that the reservoir is connected to the pressure connection.

25 9. A displacement pump as set forth in claim 8 characterised in that the gas venting valve is connected in series with the pressure valve, the gas venting valve being arranged closer to the delivery chamber.

 10. A displacement pump as set forth in one of claims 1 through 9 characterised in that the reservoir is connected to an accumulator.

30 11. A metering installation comprising a pressure line in which delivery fluid is contained at a pressure p_2 , a suction line in which delivery fluid is contained at a pressure $p_1 < p_2$, and a displacement pump as set forth in one of claims 1 through 10, wherein the pressure line is connected to the pressure connection and the suction line to the suction connection.

12. A metering installation as set forth in claim 10 characterised in that the reservoir contains delivery fluid at a pressure p_3 , wherein $p_1 < p_3 < p_2$.

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