

(19) **DANMARK**

(10) **DK/EP 3123030 T3**



Patent- og
Varemærkestyrelsen

(12) Oversættelse af
europæisk patentskrift

-
- (51) Int.Cl.: **F 04 C 25/02 (2006.01)** **F 04 C 18/16 (2006.01)** **F 04 C 28/06 (2006.01)**
- (45) Oversættelsen bekendtgjort den: **2019-10-14**
- (80) Dato for Den Europæiske Patentmyndigheds bekendtgørelse om meddelelse af patentet: **2019-08-07**
- (86) Europæisk ansøgning nr.: **14715334.0**
- (86) Europæisk indleveringsdag: **2014-04-07**
- (87) Den europæiske ansøgnings publiceringsdag: **2017-02-01**
- (86) International ansøgning nr.: **EP2014056938**
- (87) Internationalt publikationsnr.: **WO2015144254**
- (30) Prioritet: **2014-03-24 WO PCT/EP2014/055822**
- (84) Designerede stater: **AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR**
- (73) Patenthaver: **Ateliers Busch S.A., Rue des Moissons , Zone Industrielle, 2906 Chevenez, Schweiz**
- (72) Opfinder: **MÜLLER, Didier, rue du Stand 41, CH-2800 Delémont, Schweiz**
LARCHER, Jean-Eric, 8 rue Jean Moulin, F-90100 Delle, Frankrig
ILTCHEV, Théodore, 13, rue d'Ajoie, F-90600 Grandvillars, Frankrig
- (74) Fuldmægtig i Danmark: **Plougmann Vingtoft A/S, Strandvejen 70, 2900 Hellerup, Danmark**
- (54) Benævnelse: **FREMGANGSMÅDE TIL PUMPNING I ET SYSTEM AF VAKUUMPUMPER SAMT SYSTEM AF VAKUUMPUMPER**
- (56) Fremdragne publikationer:
WO-A1-03/093678
WO-A2-2011/061429
WO-A2-2014/012896
JP-A- 2007 100 562

PUMPING METHOD IN A SYSTEM OF VACUUM PUMPS AND SYSTEM OF VACUUM
PUMPS

Technical field of the invention

5 The present invention relates to a pumping method enabling the performance to be improved in terms of flow rate and final vacuum in a system of vacuum pumps in which the main pump is a dry screw-type vacuum pump, and this while reducing the temperature of the exit gases and the system's consumption of electric energy. The present invention also relates to a system of vacuum pumps which can be used to achieve
10 the method according to the present invention.

Prior art

The general trends to increase the performance of vacuum pumps, to reduce the costs of installations and of the consumption of energy in industries such as the chemical industry,
15 the pharmaceutical industry, vacuum deposition, semi-conductors, etc. have brought significant developments in terms of performance, energy saving, bulk, in the drives, etc.

The state of the art shows that in order to improve the final vacuum additional stages have to be added in the vacuum pumps of the multi-staged Roots type or multi-staged
20 claw type. For dry screw-type vacuum pumps additional turns have to be given to the screw and/or the rate of internal compression has to be increased.

The speed of rotation of the pump plays a very important role which defines the operation of the pump in the different phases of evacuation of the chambers. With the rates of
25 internal compression of the pumps available on the market (the range of which is, for example, between 2 and 20), the electric power required in the pumping phases at the suction pressures between atmospheric pressure and about 100 mbar or in other words a strong mass flow rate would be very high. The commonplace solution is to use a variable speed drive which enables the reduction or the increase of speed and consequently of the
30 capacity as a function of different criteria of pressure type, maximal flow, limit torque, temperature, etc. But during periods of operation at reduced rotational speed there are drops in flow rate at high pressure, the flow rate being proportional to the speed of rotation. The variation in speed by variable frequency drive imposes additional costs and bulkiness. Another commonplace solution is the use of valves of bypass type at certain

stages in the multi-staged vacuum pumps of Roots or claw type, or respectively at certain well defined positions along the screws in dry screw-type vacuum pumps. This solution requires numerous parts and presents problems of reliability.

5 The state of the art concerning vacuum pump systems aiming at an improvement of the final vacuum and the increase of the flow rate shows booster pumps of Roots type arranged upstream from primary dry pumps. This type of system is bulky, and operates either with bypass valves having problems of reliability or by employing means of measurement, checking, adjustment or automatic control. However, these means of
10 checking, adjustment or automatic control must be pilot operated in an active way, which necessarily results in an increase in the number of components of the system, in its complexity and in its cost.

The document WO 2014/012896A2 proposes using downstream a primary vacuum pump
15 of Roots type, an ejector mounted in parallel with the exit orifice of the primary pump in order to reduce the final vacuum achievable by this type of pump. In this document, the ejector is supplied with working fluid by an external gas line which can advantageously be the same as that used for purging the primary pump of Roots type. Moreover, the document WO 2011/061429A2 demonstrates that it is possible to lower the electricity
20 consumption of a primary vacuum pump if the means of controlling the external supply of working fluid of the above-mentioned ejector are incorporated in the pumping system. The purpose of these means of controlling is to switch on and off the ejector at the times most favourable for optimal reduction of the electric power of the primary pump.

25 Finally, the document JP 2007100562A proposes to replace the source of working fluid in gas line form with an external and isolated air compressor.

Summary of the invention

The present invention has as its object to propose a pumping method in a system of
30 vacuum pumps making it possible to obtain a better vacuum than that which can be obtained with the aid of a single dry screw-type vacuum pump (around 0.0001 mbar) in a vacuum chamber.

The present invention also has as its object to propose a pumping method in a system of vacuum pumps making it possible to obtain a flow rate greater at low pressure than that which can be obtained with the aid of a single dry screw-type vacuum pump when pumping a vacuum chamber.

5

The present invention also has as object to propose a pumping method in a system of vacuum pumps making it possible to reduce the electric energy necessary for placing a vacuum chamber under vacuum and maintaining it, as well as enabling the decrease in the temperature of the exit gases.

10

These objects of the present invention are achieved with the aid of a pumping method which is produced in the context of a pumping system, the configuration of which consists essentially in a primary dry screw-type vacuum pump equipped with a gas entry orifice connected to a vacuum chamber and a gas exit orifice leading into a conduit which is equipped with a non-return valve before coming out into the atmosphere or into other equipment. The suction port of an ejector supplied with working fluid by a compressor driven by at least one shaft of the primary vacuum pump is connected in parallel to this non-return valve, its outlet going to the atmosphere or rejoining the conduit of the primary pump after the non-return valve.

20

Such a pumping method is in particular the object of the independent claim 1. Different preferred embodiments of the invention are moreover the object of the dependent claims.

25

The method consists essentially in supplying the ejector with working fluid by a compressor driven by at least one shaft of the vacuum pump and making it operate continuously all the time that the primary dry screw-type vacuum pump pumps the gases contained in the vacuum chamber through the gas inlet orifice, but also all the time that the primary dry screw-type vacuum pump maintains a defined pressure (for example the final vacuum) in the chamber by releasing the rising gases through its outlet.

30

According to a first aspect, the invention resides in the fact that the coupling of the primary dry screw-type vacuum pump and of the ejector do not require specific

measurements and equipment (for example sensors for pressure, temperature, current, etc.), automatic controls or the management of data and calculation. Consequently the system of vacuum pumps adapted for implementing the pumping method according to the present invention comprises a minimum number of components, has great simplicity and costs considerably less in relation to existing systems.

According to a second aspect, the invention resides in the fact that, thanks to the new pumping method, the primary dry screw-type vacuum pump can operate at a single constant speed, that of the electrical grid, or turn at variable speeds according to its own mode of operation. Consequently, the complexity and the cost of the system of vacuum pumps adapted for implementing the pumping method according to the present invention can be further reduced.

By its nature, the ejector integrated in the system of vacuum pumps can always operate without damage according to the present pumping method. Its dimensioning depends on a minimum consumption of working fluid for the operation of the device. It is normally single-staged. Its nominal flow rate is selected as a function of the volume of the exit conduit of the primary dry screw-type vacuum pump limited by the non-return valve.

This flow rate can be $1/500$ to $1/20$ of the nominal flow rate of the primary dry screw-type vacuum pump, but it can also be less than or more than these values. The working fluid for the ejector can be air, but also others gases, for example nitrogen.

The non-return valve placed in the conduit at the exit of the primary dry screw-type vacuum pump can be a commercially available standard element. It is dimensioned according to the nominal flow rate of the primary dry screw-type vacuum pump. In particular, it is provided that the non-return valve closes when the pressure at the suction end of the primary dry screw-type vacuum pump is between 500 mbar absolute and the final vacuum (for example 100 mbar).

According to another variant, the ejector is multi-staged.

According to yet another variant, the ejector can be made of material having increased chemical resistance to substances and gases commonly used in the semi-conductor industry, both in the mono-staged ejector variant and in that of the multi-staged ejector.

5 The ejector is preferably of small size.

According to another variant, the ejector is integrated in a cartridge which incorporates the non-return valve.

10 According to yet another variant, the ejector is integrated in a cartridge which incorporates the non-return valve and this cartridge itself is housed in an exhaust silencer attached to the gas exit orifice of the primary dry screw-type vacuum pump.

15 According to the operating method of the system of vacuum pumps according to the invention, the ejector always pumps in the volume between the gas exit orifice of the primary dry screw-type vacuum pump and the non-return valve.

20 According to another variant of the present invention, the compressor can suck atmospheric air or the gases in the gas exit conduit after the non-return valve. The presence of the compressor makes the system of screw pumps independent of a source of compressed gas, which can suit certain industrial environments.

25 At the start of an evacuation cycle of the chamber, the pressure there is high, for example equal to the atmospheric pressure. Given the compression in the primary dry screw-type vacuum pump, the pressure of the gases released at its exit is higher than the atmospheric pressure (if the gases at the outlet of the primary pump are released directly into the atmosphere) or higher than the pressure at the inlet of other equipment connected downstream. This causes the opening of the non-return valve.

30 When this non-return valve is open, the action of the ejector is felt very slightly since the pressure at its inlet is almost equal to that of its outlet. However, when the non-return valve closes at a certain pressure (because the pressure in the chamber has dropped in the meantime), the action of the ejector causes a gradual reduction of the difference in

pressure between the chamber and the conduit after the valve. The pressure at the exit of the primary dry screw-type vacuum pump becomes that of the inlet of the ejector, that of its outlet always being the pressure in the conduit after the non-return valve. The more the ejector pumps, the more the pressure reduces at the outlet of the primary dry screw-type vacuum pump, in the volume limited by the closed non-return valve, and consequently the pressure difference decreases between the chamber and the outlet of the primary dry screw-type vacuum pump. This slight difference reduces the internal leaks in the primary dry screw-type vacuum pump and brings about a lowering of the pressure in the chamber which improves the final vacuum. Moreover the primary dry screw-type vacuum pump consumes less and less energy for the compression and produces less and less heat of compression.

On the other hand, it is also clear that study of the mechanical concept seeks to reduce the volume between the gas exit orifice of the primary dry screw-type vacuum pump and the non-return valve with the aim of lowering the pressure there more quickly.

Brief description of the drawings

The particularities and the advantages of the present invention will appear with more details as part of the description that follows with examples of vacuum pump systems given by way of illustration and in a non-limiting way with reference to the attached drawings which represent:

- FIG. 1 represents schematically a first system of vacuum pumps pumping; and
- FIG. 2 represents schematically a second system of vacuum pumps.

Detailed description of the drawings

FIG. 1 represents a first system of vacuum pumps SP adapted to implement a pumping method.

This system of vacuum pumps SP comprises a chamber 1, which is connected to the suction orifice 2 of a primary dry screw-type vacuum pump 3. The gas exit orifice of the primary dry screw-type vacuum pump 3 is connected to the conduit 5. A non-return release valve 6 is placed in the conduit 5, which, after this non-return valve, continues into the gas exit conduit 8. The non-return valve 6, when it is closed, enables the

formation of a volume 4, contained between the gas exit orifice of the primary vacuum pump 3 and the valve itself. The system of vacuum pumps SP also comprises an ejector 7, connected in parallel to the non-return valve 6. The suction orifice of the ejector is connected to the volume 4 of the conduit 5 and its release orifice is connected to the conduit 8. The supply conduit 9 provides the working fluid for the ejector 7.

FIG. 2 represents a second system of vacuum pumps SP adapted to implement a pumping method.

Compared with the system represented in FIG. 1, the system represented in FIG. 2 further comprises a compressor 10 which provides the gas flow rate at the pressure necessary for the operation of the ejector 7.

One embodiment of the invention plans for the compressor 10 to be driven by at least one shaft of the primary dry screw-type pump 3. The energy consumption for it to be able to supply the gas flow rate at the pressure required in order to operate the ejector 7 is generally smaller (e.g. around 3% to 5%) compared with the gain made on the energy consumption of the main pump 3. The compressor 10 can suck atmospheric air or the gases in the gas exit conduit 8 after the non-return valve 6. Its presence makes the system of vacuum pumps independent of a source of compressed gas, which can suit certain industrial environments.

From the start-up of the primary dry screw-type pump 3, the working fluid for the ejector 7 is supplied by the compressor 10. The primary dry screw-type pump 3 sucks the gases in the chamber 1 by the conduit 2 connected at its inlet and compresses them to then release them to its outlet in the conduit 5 by the non-return valve 6. When the closing pressure of the non-return valve 6 is reached, it closes. From this time the pumping of the ejector 7 gradually lowers the pressure in the volume 4 as far as the value of its limit pressure. In parallel, the power consumed by the primary dry screw-type vacuum pump 3 gradually decreases. This occurs in a short space of time, for example for a certain cycle in 5 to 10 seconds.

With a suitable adjustment of the flow rate of the ejector 7 and the closing pressure of the non-return valve 6 according to the flow rate of the primary dry screw-type vacuum pump 3 and the volume of the chamber 1, it is moreover possible to reduce the time before the closing of the non-return valve 6 in relation to the duration of the evacuation cycle and thus reduce the losses in working fluid during this time of operation of the ejector 7 without effect on the pumping. Also, these "losses" which are small, are taken into account in the energy consumption balance. However, the advantage of the simplicity credits an excellent reliability of the system as well as a price 10% to 20% less in comparison to similar pumps equipped with programmable logic controller and or variator, controlled valves, sensors, etc.

Certainly, the present invention is subject to numerous variations as to its implementation. It will be understood that it is inconceivable exhaustively to identify all possible embodiments. Of course it is possible to replace a means described with an equivalent means without departing from the scope of the present invention. All these modifications form part of the knowledge common to persons skilled in the field of vacuum technology.

Patentkrav

1. Fremgangsmåde til pumpning i et system af vakuumpumper (SP) omfattende:
- en primær tør snekke-vakuumpumpe (3) med en gasindgangsåbning (2) forbundet med et vakuumkammer (1) og en gasudgangsåbning (4), som
 - 5 fører ud i en ledning (5), inden den munder ud i gasudgangen (8) i systemet af vakuumpumper (SP),
 - en tilbageslagsventil (6) placeret i ledningen (5) mellem gasudgangsåbningen (4) og gasudgangen (8), og
 - en med tilbageslagsventilen (6) parallelforbunden ejektor (7),
 - 10 - en kompressor (10),

idet fremgangsmåden er **kendetegnet ved, at**

- kompressoren (10) drives af mindst en af akslerne i den primære snekke-vakuumpumpe (3);
- den primære tørre snekke-vakuumpumpe (3) sættes i drift for at pumpe de i
- 15 vakuumkammeret (1) indeholdte gasser gennem gasudgangsåbningen (4); ejektoren (7) samtidig forsynes med driftsfluid af kompressoren (10); og ejektoren (7) fortsat forsynes med driftsfluid hele den tid, i hvilken den primære tørre snekke-vakuumpumpe (3) forsynes af en energikilde og evakuerer vakuumkammeret (1)

20

2. Fremgangsmåde til pumpning ifølge krav 1, **kendetegnet ved, at** den anvender en ejektor (7) hvis udgang støder til ledningen (5) efter tilbageslagsventilen (6).

- 25 3. Fremgangsmåde til pumpning ifølge et hvilket som helst af kravene 1 til 2, **kendetegnet ved, at** ejektorens (7) nominelle strømhastighed vælges som funktion af rumfanget i udløbsledningen (5) fra den primære tørre snekke-vakuumpumpe (3), som begrænses af tilbageslagsventilen (6).

- 30 4. Fremgangsmåde til pumpning ifølge et hvilket som helst af kravene 1 til 3, **kendetegnet ved, at** ejektorens (7) driftsfluid er trykluft og/eller nitrogen.

5. Fremgangsmåde til pumpning ifølge et hvilket som helst af kravene 1 til 4, **kendetegnet ved, at** tilbageslagsventilen (6) lukkes, når den primære tørre
- 35 snekke-vakuumpumpes (3) sugetryk befinder sig mellem 500 mbar absolut og det

endelige vakuum.

6. Fremgangsmåde til pumpning ifølge et hvilket som helst af kravene 1 til 5, **kendetegnet ved, at** den anvender en ejektor (7), som er fremstillet af et materiale med forøget kemisk modstandsdygtighed over for de stoffer og gasser, der traditionelt anvendes i halvlederindustrien.

7. Fremgangsmåde til pumpning ifølge et hvilket som helst af kravene 1 til 6, **kendetegnet ved, at** den anvender en ejektor (7), som er integreret i en kassette, der indeholder tilbageslagsventilen (6).

8. Fremgangsmåde til pumpning ifølge krav 7, **kendetegnet ved, at** den anvender kassetten indsat i en udstrømningslyddæmper, der er fastgjort til gasudgangsåbningen (5) fra den primære tørre snække-vakuumpumpe (3).

15

9. System af vakuumpumper (SP) omfattende:

- en primær tør snække-vakuumpumpe (3) med en gasindgangsåbning (2) forbundet med et vakuumkammer (1) og en gasudgangsåbning (4), som fører ud i en ledning (5), inden den munder ud i gasudgangen (8) i systemet af vakuumpumper (SP),
- en tilbageslagsventil (6) placeret i ledningen (5) mellem gasudgangsåbningen (4) og gasudgangen (8), og
- en med tilbageslagsventilen (6) parallelforbunden ejektor (7),
- en kompressor (10),

idet systemet af vakuumpumper (SP) er **kendetegnet ved, at** kompressoren (10) drives af mindst en af akslerne i den primære snække-vakuumpumpe (3); ejektoren (7) er indrettet til at kunne forsynes med driftsfluid af kompressoren (10) hele den tid, i hvilken den primære tørre snække-vakuumpumpe (3) forsynes af en energikilde og evakuerer vakuumkammeret (1).

10. System af vakuumpumper ifølge krav 9, **kendetegnet ved, at** udgangen fra ejektoren (7) støder til ledningen (5) efter tilbageslagsventilen (6).

11. System af vakuumpumper ifølge et hvilket som helst af kravene 9 til 10, **kendetegnet ved, at** ejektorens (7) nominelle strømningshastighed vælges som funktion af rumfanget af udgangsledningen (5) fra den primære tørre snække-vakuumpumpe (3), som begrænses af tilbageslagsventilen (6).

5

12. System af vakuumpumper ifølge et hvilket som helst af kravene 9 til 11, **kendetegnet ved, at** det er udformet til som driftsfluid til ejektoren (7) at anvende trykluft og/eller nitrogen.

10 **13.** System af vakuumpumper ifølge et hvilket som helst af kravene 9 til 12, **kendetegnet ved, at** tilbageslagsventilen (6) er udformet til at lukkes, når den primære tørre snække-vakuumpumpes (3) sugetryk befinder sig mellem 500 mbar absolut og det endelige vakuum.

15 **14.** System af vakuumpumper ifølge et hvilket som helst af kravene 9 til 13, **kendetegnet ved, at** ejektoren (7) er fremstillet af et materiale med forøget kemisk modstandsdygtighed over for de stoffer og gasser, der traditionelt anvendes i halvlederindustrien.

20 **15.** System af vakuumpumper ifølge et hvilket som helst af kravene 9 til 14, **kendetegnet ved, at** ejektoren (7) er integreret i en kassette, som indeholder tilbageslagsventilen (6).

16. System af vakuumpumper ifølge krav 15, **kendetegnet ved, at** kassetten er
25 indsat i en udstrømningslyddæmper, som er fastgjort til den primære tørre snække-vakuumpumpes (3) gasudgangsåbning (5).

1/1

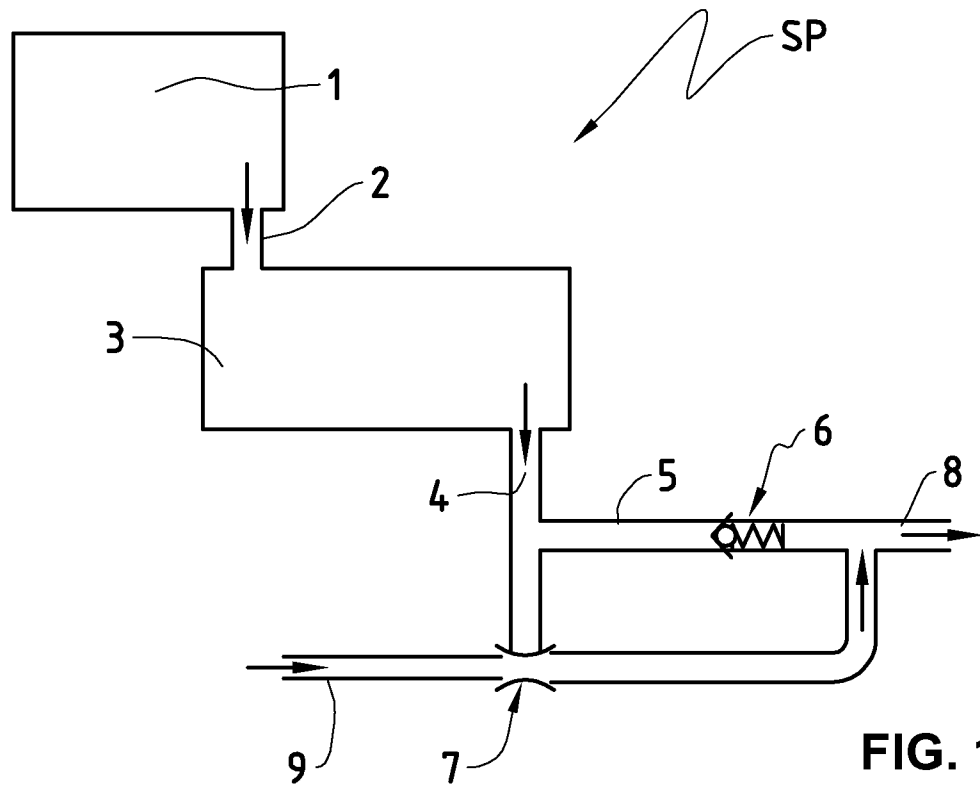


FIG. 1

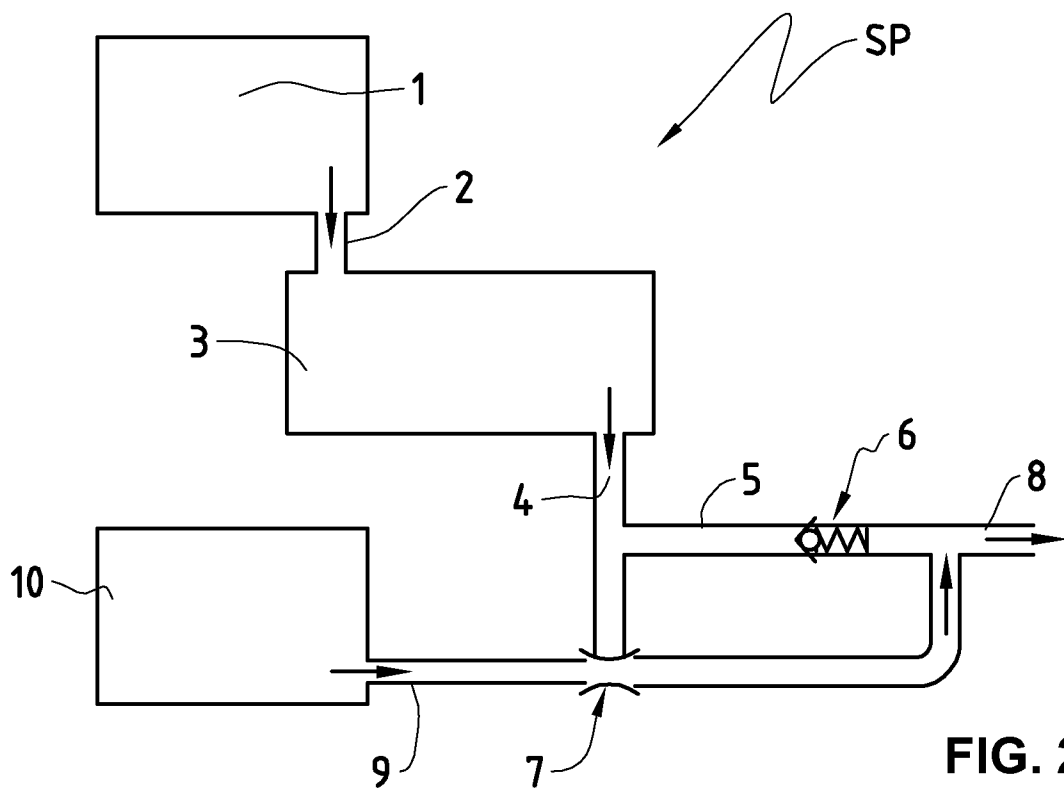


FIG. 2