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DescriptionTechnical field of the invention

5 This invention relates generally to the technical field of positive-displacement machines and to installations comprising such positive-displacement machines. This invention is concerned in particular with positive-displacement machines intended to receive compressible fluids (such as air) and that can be used as pumping machines.

10 Specifically, but not exclusively, this invention relates to the field of pumping groups or installations comprising at least one first positive-displacement machine and a second positive-displacement machine, as well as the field of methods for controlling pumping installations of this type.

15 Prior art

A large number of industrial or research processes (e.g. in the food, chemical, pharmaceutical sectors, etc.) nowadays requires a more or less high vacuum (typically in the range between 1 and 10^{-4} mbar).

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In order to produce this vacuum, vacuum pumps, that is to say positive-displacement machines capable of removing more or less completely the air (or other gas, or also a gas mixture) contained in an enclosed volume or enclosure (e.g. in a "clean room" used for the production of printed circuits), have already been in use for many years.

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Different types of vacuum pumps are currently known. Among the most widely known and commonly used, there may be mentioned in particular vane pumps, liquid ring pumps, screw pumps, spiral pumps (or scroll pumps) or also lobe pumps (or Roots pumps). Each of these different types of vacuum pumps has certain advantages (and disadvantages) which make them especially suitable for use in particular applications.

30 Since the characteristics of the various types of vacuum pumps are well known to those skilled in the art, a detailed description of the various properties does not appear to be necessary.

In order to improve certain performances of vacuum pumps, the creation of pumping units or installations has also been known for a long time, in particular by combining two or more vacuum pumps. Such a configuration typically consists of a so-called “primary”
5 pump which is connected to the enclosure that is to be evacuated and which first of all produces a so-called “primary” vacuum, i.e. pressures approximately in the range between 1 bar (10^3 mbar) and 1 mbar. The primary vacuum created by this primary pump is then taken up by a so-called “secondary” pump, connected in series with the primary pump, which performs a harder vacuum. The pressures at the outlet of a secondary pump
10 are typically between 1 and 10^{-4} mbar, though lower pressures are also possible.

A typical installation comprising two pumps is a combination of a Roots pump with another pump, e.g. a screw pump. Of course, arrangements with three (or more) pumps are also possible, as well as installations with pumps connected in parallel or with a
15 combination of connections in series and in parallel.

In addition to the pumps, such a pumping group typically comprises one or more valves, as well as an electronic and/or mechanical control module to control the flow of gas between the inlet and the outlet of the system. The particular features of the installation
20 and collaboration of the various elements in a conventional pumping group are also part of the typical knowledge of a person skilled in the art in the field of vacuum technology, and accordingly a detailed description will not be necessary at this point.

All positive-displacement machines used as vacuum pumps have the characteristic
25 feature that they become hot during their operation. On the one hand, the principle on which the majority of vacuum pumps operates causes the pumped gases to heat up between the inlet and the outlet of the system due to the enforced decrease in volume and the resulting increase in pressure. This increase in the temperature of the gases follows directly from the laws of physics and cannot be completely eliminated. On the
30 other hand, the secondary effects, such as friction between the rotating parts in the pump, also result in an increase in the temperature of the pump itself. This heating again results in an increase in the temperature of the gases inside the pumps.

A raised temperature within a pumping group is undesirable. It can in particular cause serious operating problems of the positive-displacement machines owing for example to the chemical and/or physical reactions of the pumped gases. Some gases contain in particular elements that can sublime or condense at high temperatures, thereby
5 producing residues within the pumps. Over time, these residues may result in a seizure or other malfunction of the pumps. Also, too high a temperature inside the pumps is very unfavourable for an optimal output of the pumps, since it can cause a significant expansion of the metal components.

10 In order to overcome these disadvantages, various cooling methods have already been implemented in the various vacuum pumps. Thus, air-cooled pumps exist, in particular with fins or other similar elements on their outer surface in order to increase the area of the surface that is exposed to the air and to promote cooling of the pump mechanism by the ambient air. Other pumps have a liquid cooling system, in particular water or oil. For
15 example, in a lubricated vane pump the vanes slide on a surface lubricated with oil. This oil serves both for the lubrication of the contact surface in order to achieve an easier sliding and to cool the pump.

However, all these cooling mechanisms have a major disadvantage, particularly on
20 account of the fact that they make the pumps both more complex, more expensive and more susceptible to malfunction. In addition, the cooling fluids normally need to be filtered, purified and/or changed from time to time, which makes the handling of the pumps also more complicated and expensive.

25 US patent No. 4 699 570 describes a pumping installation in which control valves are controlled between multiple paths for the gas flow depending on the pressure at the discharge from a downstream pump.

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Brief summary of the invention

The object of the present invention is therefore to provide a solution to this problem of elevated temperatures in vacuum pumps and/or in pumping groups, without the use of complex cooling systems.

- 5 Another result that the present invention aims to achieve is a pumping installation in which the performance is maintained over time.

To this end, the object of the invention is a pumping installation according to claim 1, and also a method of control according to claim 9. The more detailed embodiments are
10 disclosed in the dependent claims and in the description.

More specifically, the present invention relates to a pumping installation comprising at least a first positive-displacement machine and a second positive-displacement machine, and also a control module, in which pumping installation a gas is evacuated from an
15 enclosed volume by means of the first positive-displacement machine and/or the second positive-displacement machine, and in which the pumping installation furthermore comprises at least one control valve which is controlled by the control module in order to adjust the gas flow between the enclosed volume and the outlet of the pumping
installation.

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The main advantage of the present invention lies in the fact that the proposed pumping installation has means capable of controlling in a precise manner the flow of gas to be pumped between the inlet and the outlet of the system. In this way, the collaboration between the positive-displacement machines can be adapted to the specific needs of the
25 situation, which means that it is very easy to control the performance of the system. Consequently, it is also possible and easy to control the heating of the positive displacement machines.

At this point it should be emphasised that the present invention does not relate only to a
30 pumping installation according to the aforementioned embodiments but also relates to a method for controlling such a pumping installation.

Brief description of the drawings

The invention will be readily understood on reading the following description given by way of non-limiting example with regard to the accompanying drawings which schematically represent:

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Fig. 1: a block diagram of a pumping installation according to a first embodiment of the present invention;

10 Fig. 2: a schematic diagram representing the evolution of the pumping capacity (also termed "output") in the enclosed volume, evacuated only with a first positive displacement machine;

15 Fig. 3: a schematic diagram representing the evolution of the temperature of the first positive-displacement machine, corresponding to the evolution of the pumping capacity in Fig. 2;

Fig. 4: a schematic diagram representing the evolution of the pumping capacity in the enclosed volume, evacuated only with a second positive displacement machine;

20 Fig. 5: a schematic diagram representing the evolution of the temperature of the second positive-displacement machine, corresponding to the evolution of the pumping capacity in Fig. 4;

25 Fig. 6: a schematic diagram representing the evolution of the pumping capacity in the enclosed volume according to the present invention, evacuated both with the first and second positive displacement machines;

30 Fig. 7: a schematic diagram representing the evolution of the temperature of the first and of the second positive-displacement machine, corresponding to the evolution of the pumping capacity in Fig. 6;

Fig. 8: a block diagram of a pumping installation according to a second embodiment of the present invention;

Fig. 9: a block diagram of a pumping installation according to a third embodiment of the present invention; and

5 Fig. 10: a block diagram of a pumping installation according to a fourth embodiment of the present invention.

Detailed description of the invention

10 Fig. 1 represents a block diagram of a pumping installation IP according to an embodiment of the present invention. In Fig. 1, a first positive-displacement machine is represented in a simplified manner by a rectangle identified by the reference numeral 10 and a second positive-displacement machine is represented by another rectangle identified by the reference sign 20. Also shown schematically in Fig. 1 is an enclosed volume VE which is
15 evacuated by means of the pumping installation IP. This enclosed volume VE may correspond to a clean room (i.e. a room in which the temperature, the humidity and/or the pressure are controlled with the aim of creating and maintaining the environmental conditions necessary for various industrial or research applications), a production enclosure (for example, in a machine tool), or any other volume in which the pressure has
20 to be precisely controlled.

In the pumping installation IP according to the present invention, the first positive-displacement machine 10 can in particular be a screw pump. A screw pump consists essentially of two parallel screws which are rotationally driven in opposite directions. As
25 a result of this rotation, the gases within the pump can be transported between the inlet and the outlet of the pump. Screw pumps are dry pumps, and are therefore pumps in which the pumped gases never come into contact with lubricating liquids that could result in contamination. Owing to this feature, screw pumps can be used in applications that require a high level of hygiene (e.g. in the food industry). Of course, the positive-
30 displacement machine 10 can be realised by any other suitable type of pump.

This first positive-displacement machine 10 is connected to the enclosed volume VE via a conduit (or pressure line) LP1. This conduit LP1 can in particular correspond to a

conventional pipe, of metal or any other suitable material. Of course, other types of conduit LP1 are also possible. The first positive-displacement machine 10 is therefore disposed and arranged so as to directly discharge the air (or any other gas within the enclosed volume VE) and releases it at its outlet, which is typically carried out via an exhaust port.

Another conduit LP2 is connected to the exhaust port of the first positive-displacement machine 10. Like the conduit LP1 which connects the enclosed volume VE to the first positive-displacement machine 10, the conduit LP2 may be a conventional pipe, but also realised in another suitable way. The conduit LP2 thus collects the gases at the outlet of the positive displacement machine 10 and then channels them to the second positive-displacement machine 20 via a third conduit LP3.

The second positive-displacement machine 20 that receives the flow of the gases that have been evacuated from the enclosed volume by the first positive-displacement machine 10 via the conduit LP3 can in particular be a vane pump. Vane pumps are composed of a stator and a rotor with sliding vanes that rotate tangentially to the stator. During the rotation, the vanes remain in contact with the walls of the stator. The walls of the stator in an area are covered by an oil bath, which ensures that the pump is liquid-tight and also that the moving parts are lubricated. Vane pumps are therefore not dry pumps, and the pumped gases can come into contact with the lubricants. These pumps are therefore normally not used in applications having stringent hygiene standards. Here too the positive-displacement machine 20 is not necessarily a vane pump, and it can also be realised by another suitable type of pump.

The outlet (the exhaust port) of the second positive-displacement machine 20 is connected to a fourth conduit LP4 which serves to evacuate the gases pumped by the second positive-displacement machine 20 at the outlet of the pumping installation IP. The conduit LP4 may also correspond to a conventional pipe, of metal or other suitable material. Of course, other types of conduit are also conceivable, as well as a solution in which the conduit LP4 is not provided and the gases leaving the positive-displacement machine 20 are passed directly to the outlet of the pumping installation IP.

In the IP pumping installation according to the present invention, a control valve VC is connected between the conduits LP2 and LP3, and thus between the first positive-displacement machine 10 and the second positive-displacement machine 20. This control valve VC essentially serves to control the flow of the gases and in particular to prevent the flow of the pumped gases in the “rearwards” direction, in other words towards the positive-displacement machine 10. Such control valves are already known in the art, and their operating principle can in particular be based on a non-return valve. Of course, any other type of control valves can be used if these other valves satisfy the aforementioned conditions.

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The control valve VC can for its part be controlled by an external control module MC. The control module MC is an electronic and/or mechanical device that enables the operation of the control valve VC to be regulated so as to adjust the flow of the gases between the conduit LP1 and the conduit LP2, and therefore between the enclosed volume VE and the outlet of the pumping installation IP. To this end, a fifth conduit LP5 leading directly to the outlet of the pumping installation IP is also connected to the control valve VC.

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The pumping installation IP according to the present invention, as shown in Fig. 1, operates as follows: during the start-up of the first positive-displacement machine 10, the gases are pumped from the enclosed volume VE. Fig. 2 schematically represents a diagram showing the evolution of the pumping capacity (which is also termed “output” of the pump) in the enclosed volume VE, which is evacuated only with this first positive-displacement machine 10.

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It can readily be seen that the pumping capacity increases in a first operating range, then decreases in a second operating range, and finally remains constant after reaching a limit pressure. In parallel, Fig. 3 represents the evolution of the temperature in the first positive-displacement machine 10, which corresponds directly to the pumping capacity of the first positive-displacement machine as shown in Fig. 2. On analysing this diagram, it can readily be seen that there is a marked increase in the temperature of the positive-displacement machine 10 above a limit pressure. As already mentioned in the introduction, a large increase in temperature is generally disadvantageous.

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Fig. 4 also represents a schematic diagram showing the evolution of the pumping capacity in the enclosed volume VE, but in the case where this volume is evacuated only with the second positive-displacement machine 20. This second positive-displacement machine 20 typically shows a rather constant evolution. However, the temperature in the second positive-displacement machine 20 evolves in a similar manner to that in the positive-displacement machine 10, and thus shows a clear increase in temperature above a limit pressure.

In order to completely overcome this problem, the present invention proposes to regulate the control valve VC by means of the control module MC so as to switch the gas flow between a first path in which the gas is pumped only by the first positive-displacement machine 10, and a second path in which the gas is pumped by both the first positive-displacement machine 10 and the second positive-displacement machine 20.

In the first case, the gas evacuated from the enclosed volume VE passes through the conduit LP1 and the first positive-displacement machine 10, arrives at the control valve VC via the conduit LP2, and is then passed directly to the outlet of the pumping installation IP via the conduit LP5. In contrast to this, the gas evacuated from the enclosed volume VE in the second case first passes through the conduit LP1, the first positive-displacement machine 10 and the second conduit LP2 to arrive at the control valve VC, which directs it not to the outlet but to the second positive-displacement machine 20. After this the gas pumped by the second positive-displacement machine 20 leaves the pumping installation IP via the conduit LP4.

Normally, this switching is controlled in a time-governed manner. For example, the pumping installation IP can in a first operating phase function as in the first case described above, thus with the gases which are pumped via the first path. Then, after a certain period of time, the pumping installation IP can operate as in the second case described above, thus with the gases which are pumped via the second path.

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The switching between the first path and the second path can be programmed in a "static" manner. It would be possible for example to program a switching after an operation in the first operating mode (path VE -> LP1-> 10 -> LP2 -> VC -> LP5) of 20 or 30 seconds. In

this case the control module would count the time that has elapsed since the start-up of the pumping installation, and after reaching the pre-programmed time would give the instruction to the control valve to change the flow path of the gases.

5 However, rather than using a static switching it would also be possible to use a pressure sensor CP at the outlet of the first positive-displacement machine 10 and switch the gas flow after a certain pressure at the outlet of the first positive-displacement machine 10 has been detected. This limit pressure could be determined in a practical way for each specific application and stored in the control module MC so as to be able to be used in
10 regulating the control valve VC.

Figs. 6 and 7 show schematically the evolution of the pumping capacity in the enclosed volume VE as it is evacuated both with the first positive-displacement machine 10 and the second positive-displacement machine 20, and also the evolution of the corresponding
15 temperature.

Finally, Fig. 8 illustrates schematically a second embodiment of the present invention. Compared to the first embodiment that was shown in Fig. 1, this second embodiment of the present invention comprises a third positive-displacement machine 30 which is
20 interposed between the enclosed volume VE and the first positive-displacement machine 10. To this end, the conduit LP1 is divided into two portions, namely the conduits LP1' and LP1". Of course, other options for the interconnection are entirely conceivable.

This third positive-displacement machine 30 may typically be a Roots pump. Its function
25 corresponds to the function of a booster pump that is conventionally used in currently known pumping installations. It would of course also be possible to use another type of positive-displacement machines or to add improvements to them, without departing from the spirit of the present invention.

30 Figs 9 and 10 show respectively a third and a fourth embodiment of the present invention. These two embodiments of the present invention differ from the first and second embodiments of the present invention in a significant point that will be explained below.

In the third embodiment of the present invention, shown in Fig. 9, the pumping installation also comprises a first positive-displacement machine 10 and a second positive-displacement machine 20, which are used to evacuate the enclosed volume VE (in particular a clean room, a production enclosure or any other volume in which the pressure has to be controlled in a precise manner). As already mentioned with respect to the first embodiment of the present invention (shown in Fig.1), the first positive displacement machine 10 can be a dry pump, for example a screw pump, but also any other suitable positive-displacement machine. As regards the second positive-displacement machine 20, it can in particular be a vane pump, but it is of course possible to implement this second positive-displacement machine 20 via another suitable positive-displacement machine.

A conduit or a pressure line LP1, e.g. a conventional pipe, connects this first positive-displacement machine 10 to the enclosed volume VE. The outlet of the first positive-displacement machine 10 (then normally an exhaust port of the pump) is on its side connected to another conduit LP2, which may also be a conventional pipe but alternatively another suitable conduit. This second conduit LP2 takes the gases at the outlet of the positive-displacement machine 10 and passes them via a control valve VC to the second positive-displacement machine 20. To this end a third conduit LP3 is also provided for connecting the control valve VC to the second positive-displacement machine 20.

Just as in the pumping installations according to the first or second embodiment of the present invention, the outlet of the second positive-displacement machine 20 is connected to a fourth conduit LP4, which serves to evacuate the gases pumped by the second positive-displacement machine 20 at the outlet of the pumping installation. Again, this conduit LP4 can also correspond to a conventional pipe, of metal or any other suitable material. Of course, other types of conduit are also conceivable, as well as a solution in which the conduit LP4 is not provided and the gases leaving the positive-displacement machine 20 are directly passed to the outlet of the pumping installation IP.

As already mentioned, the control valve VC is connected between the first positive-displacement machine 10 and the second positive-displacement machine 20. The function

of this control valve VC is, also in this third embodiment of the present invention, primarily to control the flow of the gases and in particular to prevent the flow of the pumped gases in the rearwards direction, therefore towards the positive-displacement machine 10. In order to control this control valve VC, the IP pumping installation according to this third
5 embodiment of the present invention also comprises a control module MC. It is this control module MC that directs the operation of the control valve VC so that it can regulate the flow of the gases between the conduit LP1 and the conduit LP2, and thus between the enclosed volume VE and the outlet of the pumping installation IP. To this end, a fifth conduit LP5 leading directly to the outlet of the pumping installation IP can
10 also be provided at the outlet of the control valve VC.

It is thus evident that the pumping installation IP according to this third embodiment of the present invention corresponds in its structure essentially to the pumping installation IP of the first embodiment of the present invention, shown in Fig. 1. However, the
15 operation of the pumping installation IP according to this third embodiment differs significantly from the operation of the pumping installation IP according to the first embodiment of the present invention.

In fact, when the pumping installation IP according to this third embodiment of the present invention is switched on, shown in Fig. 9, the control valve VC is closed, that is to say it is arranged so as not to allow the flow of the gases between the first positive-displacement machine 10 and the second positive-displacement machine 20 via the conduit LP3. At this point in time, the positive-displacement machine 10 and the positive-displacement machine 20 can be started up according to the known procedures.
25 Consequently, owing to the fact that the positive-displacement machine 10 is connected directly to the enclosed volume VE, the gases contained in the enclosed volume VE can be evacuated via the positive-displacement machine 10. During this time, all these pumped gases leave the pumping installation via the conduit LP5.

30 The diagram shown in Fig. 2 illustrates the evolution of the pumping capacity (or the output of the pump) in the enclosed volume VE which is evacuated solely with the first positive displacement machine 10, and a schematic representation of the evolution of the temperature in the first positive-displacement machine 10 that corresponds to the

pumping capacity of this first positive-displacement machine 10 of Fig. 2 is illustrated in Fig. 3. These two diagrams therefore also correspond to the data that are obtained in the case which has been described with regard to the first embodiment of the present invention.

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To return to these two diagrams, it can be seen that the pumping capacity increases in a first operating range, decreases in a second operating range, and then remains constant after reaching a limit pressure. As regards Fig. 3 and the evolution of the temperature in the first positive-displacement machine 10, a marked increase in the temperature of the positive-displacement machine 10 above a limit pressure can easily be taken into account. As already mentioned in the introduction, a large increase in temperature is generally disadvantageous.

In order to overcome this temperature problem, the third embodiment of the present invention, like the first embodiment of the present invention, also proposes to regulate the control valve VC by means of the control module MC so as to switch the gas flow between a first path in which the gas is pumped only by the first positive-displacement machine 10, and a second path in which the gas is pumped by both the first positive-displacement machine 10 and the second positive displacement machine. However, the manner of implementing this regulation in the pumping installation IP according to the third embodiment differs from the manner used in the pumping installation IP according to the first embodiment of the present invention.

Nevertheless, instead of a pressure sensor, the pumping installation IP according to the third embodiment of the present invention employs a temperature sensor TP placed at the outlet of the first positive-displacement machine 10. This temperature sensor is capable of measuring the temperature of the gases at the outlet of the first positive-displacement machine 10 and transmitting this thermal information to the control module MC so that it can control the control valve VC.

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The control of the control valve VC operates in the following way: all the while the temperature detected at the outlet of the first positive-displacement machine 10 remains below a predetermined value, the control valve VC remains in the initial position, that is

to say with the conduit LP3 closed, and with the gases pumped from the enclosed volume VE released by the conduit LP5. Of course, the limit temperature may be chosen in a dynamic manner, that is to say depending on the pumped gases, in order to ensure that the temperature at the outlet of the first positive-displacement machine 10 does not exceed the critical value that would result in chemical and/or physical reactions of the pumped gases and residues inside the positive-displacement machine 10. This limit temperature can in particular be determined in a practical manner for each specific application and stored in the control module MC so as to be able to be used in the regulation of the control valve VC.

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It should be noted at this point that, during this first phase of operation of the pumping installation IP, the second positive displacement machine 20 also functions, even if it is connected to the conduit LP3 that does not contain gas to be pumped (considering that the control valve VC closes this conduit). Consequently, this second positive-displacement machine 20 tends to be heated.

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When a temperature above the predetermined limit temperature is detected via the temperature sensor TP At the outlet of the first positive-displacement machine 10, the control module MC can regulate the control valve VC so as to open the conduit LP3 to the passage of the gases leaving the first positive-displacement machine 10 and passing through the conduit LP2. At the same time, the conduit LP5 is closed. From this point in time the gas is pumped both by the first positive-displacement machine 10 and the second positive-displacement machine 20. This second positive-displacement machine 20 thus stops pumping against an empty conduit LP3 and its temperature tends to drop so as to wait for the optimal working temperature.

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Of course, the second positive-displacement machine 20 in such a configuration is capable of overheating, so much so that it is normally desirable to use a small-sized machine dimensions that are reduced as far as possible. In order to avoid this problem, this second positive-displacement machine 20 may include a more or less sophisticated cooling mechanism. In particular it is possible to use a conventional air-cooled system, a water-cooled system (or other suitable cooling liquid), or any other known system. Also, this cooling mechanism can be dynamic, i.e. can be controlled by a temperature sensor

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(independent of the TP sensor) in order to start the cooling only if the temperature of the second positive-displacement machine exceeds a predetermined value.

5 The result of this adjustment as regards the evolution of the pumping capacity in the enclosed volume VE can be seen in Figs. 6 and 7 (which also correspond to the behaviour of the pumping installation IP according to the first embodiment of the present invention).

To complete this description, it should be noted that a fourth embodiment of the present invention is shown in Fig. 10. With regard to the third embodiment of the present invention, this fourth embodiment of the present invention, like the second embodiment of the present invention (cf. Fig. 8), also comprises a third positive-displacement machine 30 (typically a Roots pump), which is interposed between the enclosed volume VE and the first positive-displacement machine 10. The function of the third positive-displacement machine 30 corresponds to the function of a booster pump that is conventionally used in pumping installations known up to now. It would of course also be possible to use another type of positive-displacement machines or to add advantages, without departing from the spirit of the present invention.

Naturally, the present invention is subject to many variations as regards its implementation. Although many embodiments have been described, it is understood that it is not possible to identify exhaustively all the possible modes. It is of course possible to replace one described means by an equivalent means without departing from the scope of the present invention. Likewise, it is perfectly possible to combine the described elements with respect to the particular embodiments, so as to create in this way new embodiments of the present invention. We also point out that the various embodiments of the present invention can of course be combined to create other suitable embodiments. In particular, it is also possible to produce a new pumping installation which comprises the main characteristic feature of the two first embodiments (that is to say a pressure sensor) together with a temperature sensor as proposed by the third and fourth embodiments of the present invention.

Patentkrav

- 1.** Pumpeanlæg (IP) omfattende mindst én første fortrængningsmaskine (10) og én anden fortrængningsmaskine (20), samt et styremodul (MC), i hvilket
- 5 pumpeanlæg (IP) en gas evakueres fra en indesluttet volumen (VE) ved hjælp af den første fortrængningsmaskine (10) og/eller den anden fortrængningsmaskine (20), hvor pumpeanlægget (IP) yderligere omfatter mindst én styreventil (VC), som styres af styremodulet (MC) og en temperatursensor (TP) til at detektere værdien af temperaturen ved udløbet af den første fortrængningsmaskine (10) for
- 10 at styre strømmen af gas mellem den indesluttede volumen (VE) og udløbet af pumpeanlægget (IP),
- kendetegnet ved, at** styremodulet (MC) er konfigureret til at styre styreventilen (VC) på sådan en måde at, på tidspunktet for en opstart af den første fortrængningsmaskine (10) og af den anden fortrængningsmaskine (20) af
- 15 pumpeanlægget (IP), mens temperaturen detekteret ved udløbet af den første fortrængningsmaskine (10) af temperatursensoren (TP) er under en forudbestemt værdi, styreventilen (VC) leder strømmen af gas mellem den indesluttede volumen (VE) og udløbet af pumpeanlægget (IP) langs en første strækning fra blandt to strækninger, hvilke er denne første strækning i hvilken gassen pumpes
- 20 udelukkende af den første fortrængningsmaskine (10) og en anden strækning i hvilken gassen pumpes af den første fortrængningsmaskine (10) og den anden fortrængningsmaskine (20).
- 2.** Pumpeanlæg ifølge krav 1, **kendetegnet ved, at** styremodulet (MC) er
- 25 konfigureret til at styre styreventilen (VC) på sådan en måde at, når en temperatur over en forudbestemt temperatur er detekteret ved hjælp af temperatursensoren (TP) ved udløbet af den første fortrængningsmaskine (10), styreventilen (VC) leder strømmen af gas langs den anden strækning.
- 30 **3.** Pumpeanlæg ifølge krav 1 eller krav 2, **kendetegnet ved, at** den første fortrængningsmaskine (10) er en tørpumpe.

4. Pumpeanlæg ifølge krav 3, **kendetegnet ved, at** den første fortrængningsmaskine (10) er en skruepumpe.
5. Pumpeanlæg ifølge et hvilket som helst af kravene 1 til 4, **kendetegnet ved, at** den anden fortrængningsmaskine (20) er en vingepumpe.
6. Pumpeanlæg ifølge et hvilket som helst af kravene 1 til 5, **kendetegnet ved, at** pumpeanlægget yderligere omfatter en tredje fortrængningsmaskine (30), serieforbundet mellem den indesluttede volumen (VE) og den første fortrængningsmaskine (10).
7. Pumpeanlæg ifølge krav 6, **kendetegnet ved, at** den tredje fortrængningsmaskine (30) er en Roots-pumpe.
8. Pumpeanlæg ifølge et hvilket som helst af de foregående krav, **kendetegnet ved, at** den anden fortrængningsmaskine (20) omfatter en kølemekanisme.
9. Fremgangsmåde til at styre et pumpeanlæg (IP) omfattende mindst én første fortrængningsmaskine (10) og én anden fortrængningsmaskine (20), samt et styremodul (MC), i hvilket pumpeanlæg (IP) en gas evakueres fra en indesluttet volumen (VE) ved hjælp af den første fortrængningsmaskine (10) og/eller den anden fortrængningsmaskine (20), hvor en styreventil (VC) styres af styremodulet (MC), som modtager information fra en temperatursensor (TP) der registrerer værdien af temperaturen ved udløbet af den første fortrængningsmaskine (10), **kendetegnet ved, at**, på tidspunktet for en opstart af den første fortrængningsmaskine (10) og af den anden fortrængningsmaskine (20) af pumpeanlægget (IP), mens temperaturen detekteres ved udløbet af den første fortrængningsmaskine (10) af temperatursensoren (TP) er under en forudbestemt værdi, styreventilen (VC) leder strømmen af gas mellem den indesluttede volumen (VE) og udløbet af pumpeanlægget (IP) langs en første strækning fra blandt to strækninger, hvilke er denne første strækning i hvilken gassen pumpes udelukkende af den første fortrængningsmaskine (10) og en anden strækning i

hvilken gassen pumpes af den første fortrængningsmaskine (10) og den anden fortrængningsmaskine (20).

10. Fremgangsmåde ifølge krav 9, **kendetegnet ved, at** en tredje

5 fortrængningsmaskine (30), serieforbundet mellem den indesluttede volumen (VE) og den første fortrængningsmaskine (10), er tilvejebragt i pumpeanlægget (IP).

11. Fremgangsmåde ifølge et hvilket som helst af kravene 9 og 10, **kendetegnet**

10 **ved, at**, når en temperatur over en forudbestemt temperatur er detekteret ved hjælp af temperatursensoren (TP) ved udløbet af den første fortrængningsmaskine (10), styreventilen (VC) leder strømmen af gas langs den anden strækning.

15 **12.** Fremgangsmåde ifølge et hvilket som helst af kravene 9 til 11, **kendetegnet**

ved, at den forudbestemte temperature er valgt afhængigt af de pumpede gasser.

13. Fremgangsmåde ifølge et hvilket som helst af kravene 9 til 12, **kendetegnet**

20 **ved, at** den forudbestemte temperature er bestemt på en praktisk måde for hver konkrete anvendelse og er lagret i styremodulet (MC) for at kunne anvendes til styringen af styreventilen (VC).

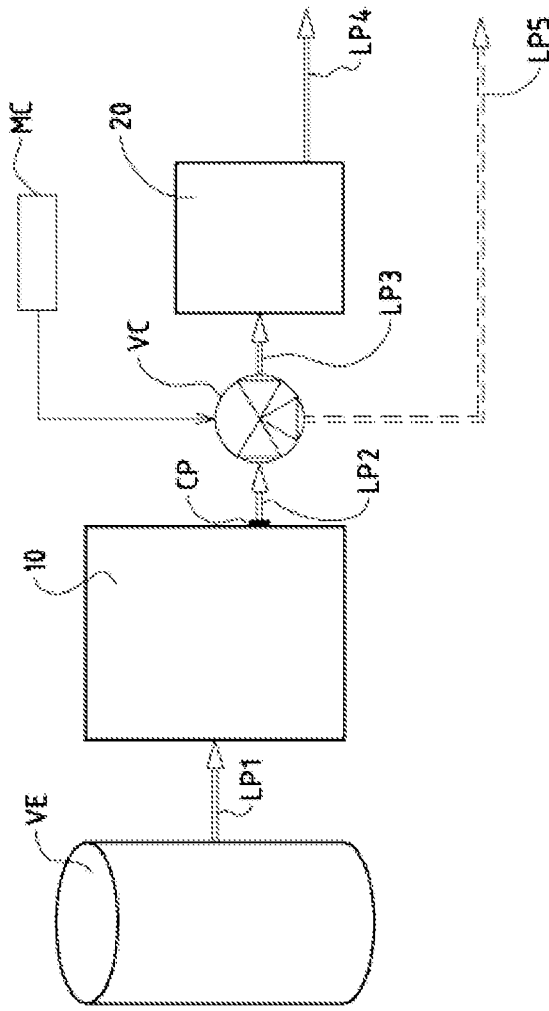


FIG. 1

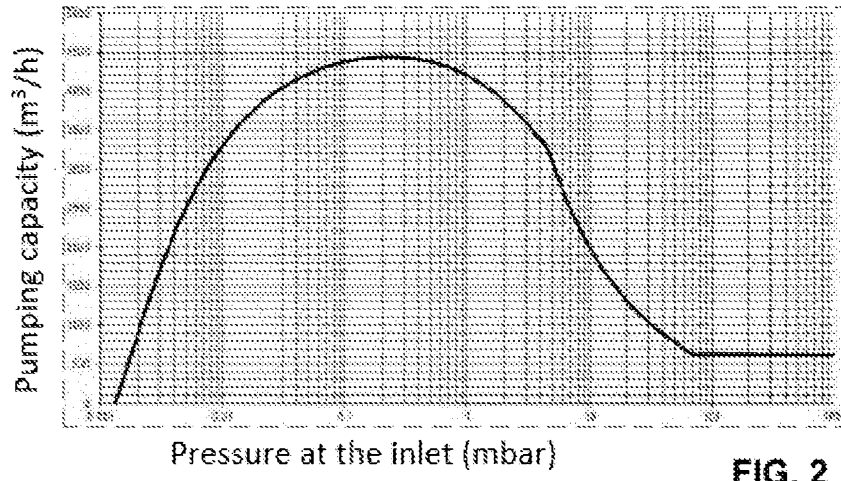


FIG. 2

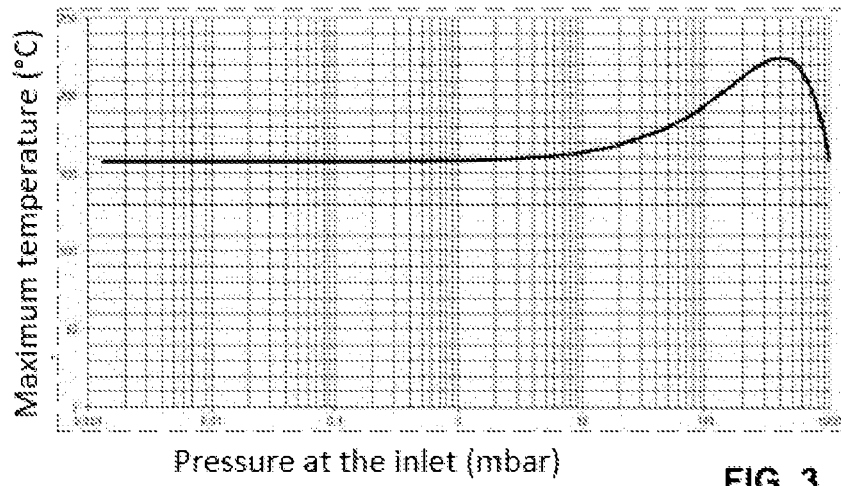


FIG. 3

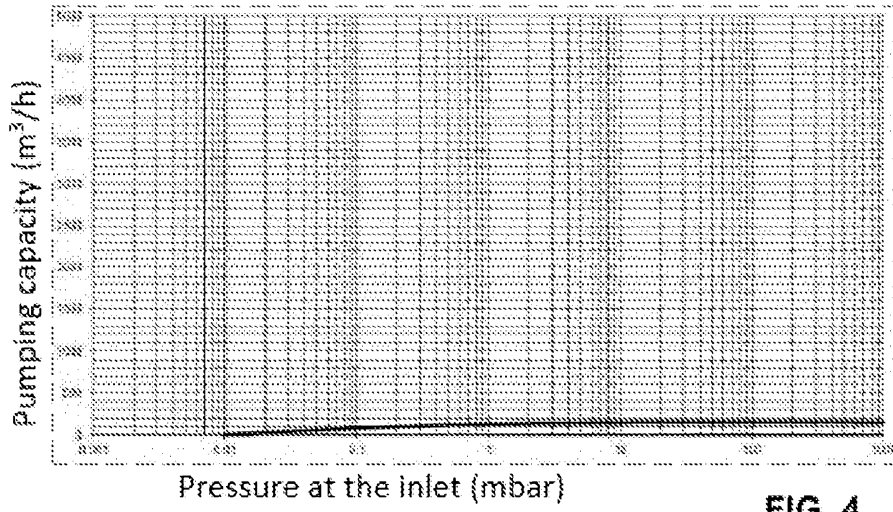


FIG. 4

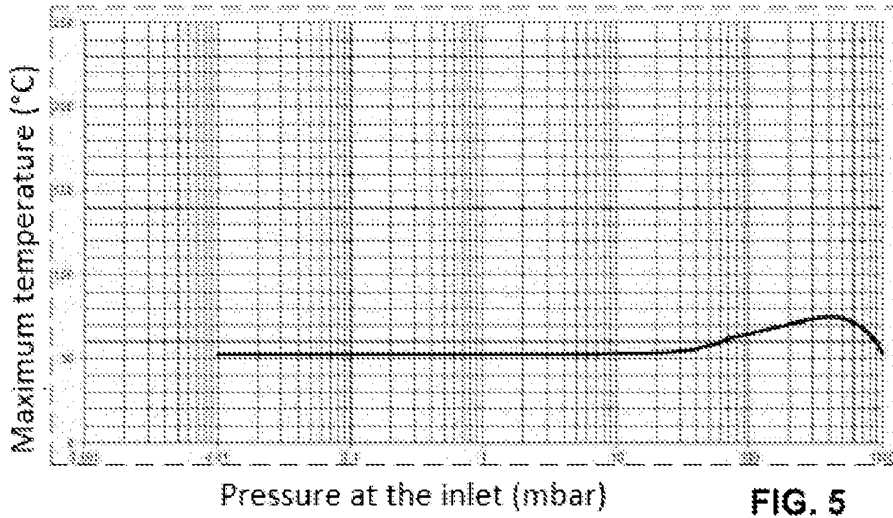


FIG. 5

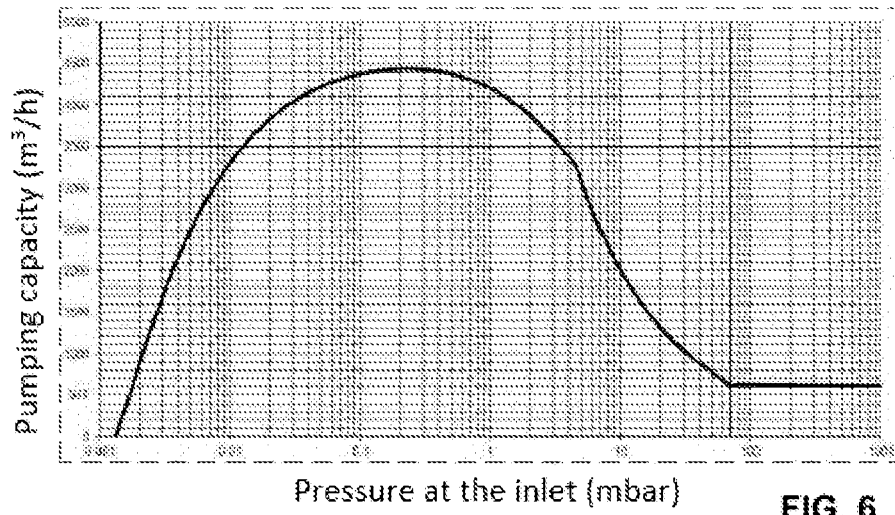


FIG. 6

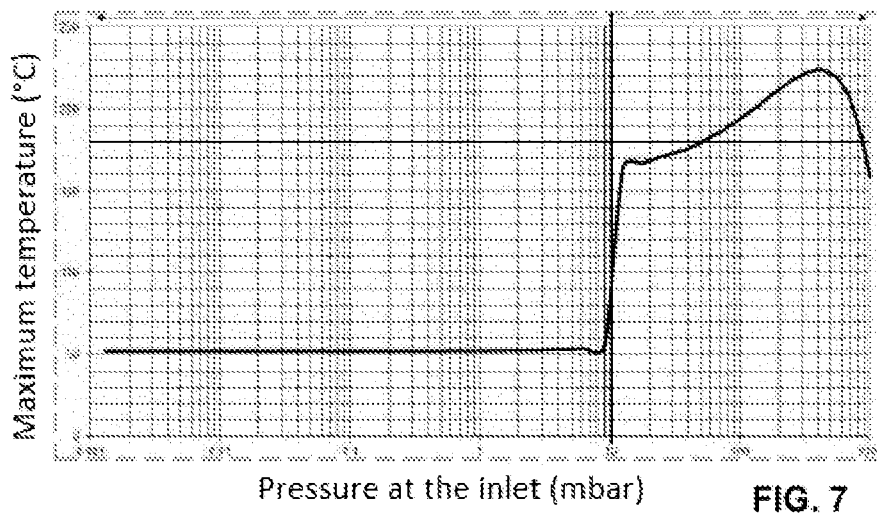


FIG. 7

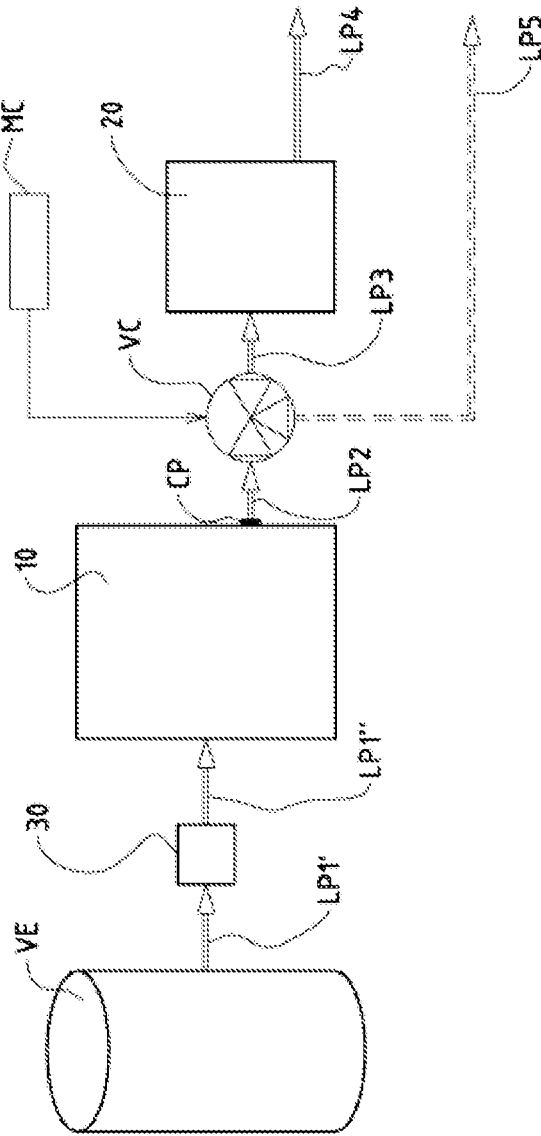


FIG. 8

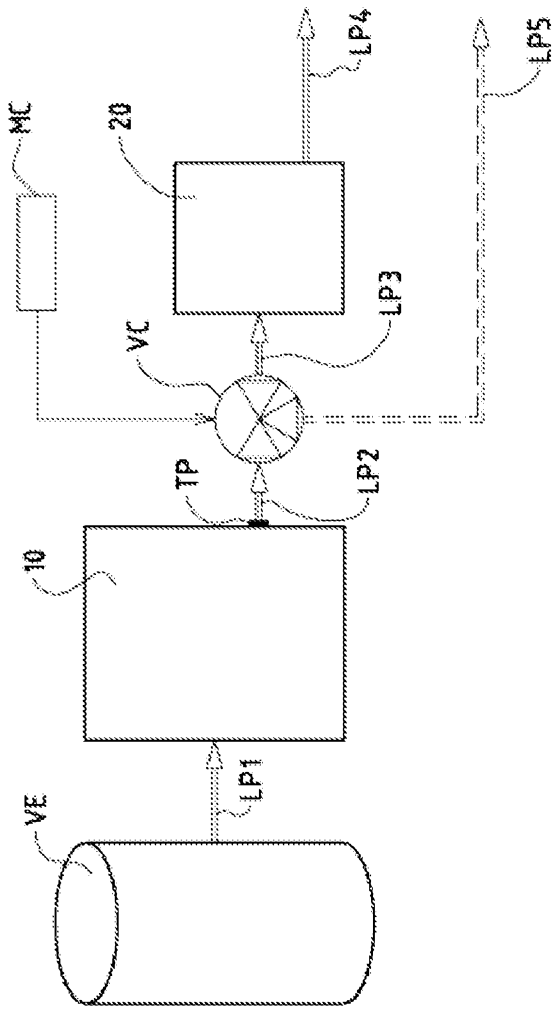


FIG. 9

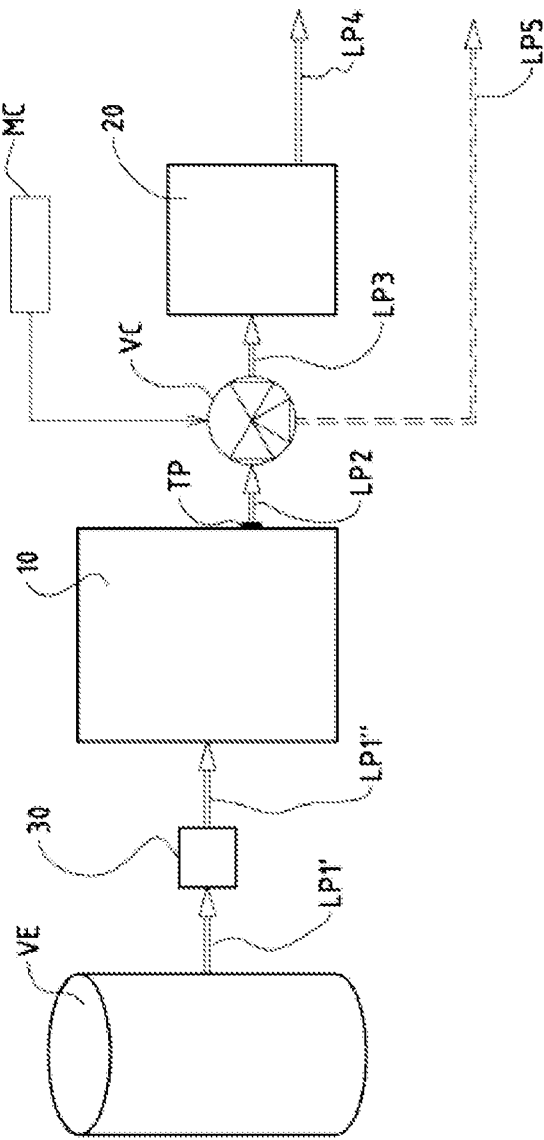


FIG. 10