

Fluid Pumping System

Field

The present application generally relates to a fluid pumping system, especially a fluid pumping system by which a liquid could be discharged at a substantially constant pressure and a substantially stable flow rate.

Background

A microfluidic platform is adopted in biomedical devices, experimental test fields or the like and integrates the functions of microfluidic drive, control, monitoring, reaction, detection and analysis.

10 As a key constituent part of the microfluidic platform, a fluid pumping system plays an important role in realization of high stability requirements for flow rates of fluids to be pumped during microfluidic experiments. Furthermore, the high stability requirements for flow rates are also necessary in some fields of chemical production.

In a conventional fluid pumping system, a mechanical pump such as a peristaltic pump, a plunger pump or the like is used as a power source to pump a fluid. However, the fluid cannot be pumped by the mechanical pump at a high constant pressure and/or a high stable flow rate to meet the microfluidic platform's requirements. Although a gas pressure can be generated in the fluid storage container as the power source to drive a fluid out of the fluid storage container to achieve pumping fluid's high stability. However, since the fluid storage container has a limited internal volume, it is
20 required to constantly refill a fluid into the fluid storage container when the microfluidic platform needs to operate for a long time period. When it is required to refill the fluid, the power source for generating the gas pressure has to be closed and thereafter a closure cover of the fluid storage container has to be opened to enable the fluid to be refilled therein, leading to that the fluid pumping system operates inconveniently and is unable to continuously pump the fluid for a long time period.

Summary

In order to solve the above issues, the present application is aimed at proposing an improved fluid pumping system which can be used in biomedical devices, microfluidic platforms, and application scenarios requiring high stable outflow to discharge a fluid at a substantial constant pressure and at
30 a substantially high stable flow rate for a long time period.

According to an aspect of the present application a fluid pumping system is provided, comprising:

- a constant pressure gas source;

- a constant pressure fluid storage container; and

a fluid refilling module, wherein the constant pressure gas source is configured to be in fluid communication with the constant pressure storage container such that a pressurized gas can be supplied from the constant pressure gas source into the constant pressure fluid storage container to drive a fluid within the constant pressure fluid storage container out of a fluid outlet of the constant pressure fluid storage container, and the fluid refilling module is configured to be in fluid communication with the constant pressure fluid storage container independent of the constant pressure gas source and the fluid outlet such that a fluid can be selectively supplied into the constant pressure storage container without affecting the fluid being driven by the pressurized gas out of the fluid outlet of the constant pressure fluid storage container.

- 10 In an embodiment, the fluid refilling module comprises a fluid refilling pump and a fluid refilling tank, and the fluid refilling tank is configured to be in fluid communication with the constant pressure fluid storage container via a pipeline in which the fluid refilling pump is connected in series such that when the fluid refilling pump is being operated the fluid can be sucked from the fluid refilling tank into the constant pressure container via the pipeline.

In an embodiment, the fluid pumping system further comprises:

a detection module including a level gauge to detect a fluid level in the constant pressure fluid storage container.

- 20 In an embodiment, the fluid refilling module is prevented from supplying the fluid into the constant pressure fluid storage container when a detected value of the fluid level is greater than a prescribed maximum fluid level value.

In an embodiment, when the detected value of the fluid level is not greater than the prescribed maximum fluid level value, the fluid refilling pump of the fluid refilling module is selectively switchable between a first mode, in which first mode the fluid can be supplied by the fluid refilling pump from the fluid refilling tank at a non-zero first flow rate, and a second mode in which second mode the fluid can be supplied by the fluid refilling pump from the fluid refilling tank at a non-zero second flow rate greater than the non-zero first flow rate.

- 30 In an embodiment, the fluid refilling pump is configured to operate in the first mode when the detected value of the fluid level is less than a prescribed fluid level value for pump normal operation and greater than a prescribed minimum fluid level value; or the fluid refilling pump is configured to operate in the second mode when the detected value of the fluid level is not greater than the prescribed minimum fluid level value.

In an embodiment, the constant pressure fluid storage container is provided with a gas inlet, a fluid outlet and a fluid refilling port which are independent of each other.

In an embodiment, the constant pressure gas source is configured to be air-tightly connected to the gas inlet of the constant pressure fluid storage container via a second pipeline such that the

pressurized gas can be supplied from the constant pressure gas source into the constant pressure fluid storage container; and a third pipeline is air-tightly connected to the fluid outlet such that the fluid can be driven out of the constant pressure fluid storage container under action of the pressurized gas.

In an embodiment, the third pipeline and/or the pipeline connected to the fluid refilling pump has a pipeline section in the constant pressure container, and the pipeline section has an opening which extends below the fluid level in the constant pressure fluid storage container.

10 In an embodiment, the constant pressure is configured such that after the pressurized gas is supplied into the constant pressure fluid storage container the fluid can be discharged out of the constant pressure fluid storage container via the third pipeline at a substantially stable flow rate.

Using the technological means of the present application, the fluid pumping system can be used to discharge the fluid at a substantially constant pressure and stable flow rate for a long time period to meet the microfluidic platform's requirements. Therefore, the fluid in the fluid storage tank of the fluid pumping system can be monitored in real time such that the constituent parts of the fluid pumping system can be operated as required to ensure automation.

Brief description to the drawings

20 The principle and various aspects of the present application will be fully understood by the following description in combination with the attached drawings. It should be noted that the drawings might be given in different ratios for illustrative purposes, which cannot be deemed to affect understanding to the present application. In the drawings:

Fig. 1 is a block diagram schematically illustrating a fluid pumping system according to an embodiment of the present application;

Fig. 2 is a view schematically illustrating the fluid pumping system according to the embodiment of the present application;

Fig. 3 is a flow chart schematically illustrating a method according to an embodiment of the present application for controlling the fluid pumping system;

30 Fig. 4 is a view schematically illustrating gas pressure variation occurring in a constant pressure fluid storage container during a fluid refilling process of the constant pressure fluid storage container of the fluid pumping system; and

Fig. 5 is a view schematically illustrating flow rate variation occurring during a fluid pumping-out process of the fluid pumping system.

Embodiments

In the drawings of the present application, those features having the same configuration or a similar function are represented by the same reference numeral respectively.

Fig. 1 is a block diagram schematically illustrating a fluid pumping system according to an embodiment of the present application. The fluid pumping system generally comprises a control module 100, a constant pressure gas source 200, a constant pressure fluid storage container 300, a detection module 400 as well as a fluid refilling module 500. In the context of the present application, the term “control module” can be understood to include a central control unit. For example, the central control unit can be a computer or a printed circuit board on which a control chip is installed.

10 For example, the computer can be a programmable computing device such as a personal computer, a microprocessor, a workstation or the like, into which programmable computing device data can be input, in which programmable computing device computation can be carried out, and from which programmable computing device instruction(s) could be output. Such a programmable computing device is equipped with a memory in which a written program can be stored. As desired, the program stored therein can be invoked therefrom and executed by the computing device. The computing device is provided with a data input unit and an instruction output unit. The data input unit is configured such that the computing device can receive data input through the data input unit. The instruction output unit is configured such that any control instruction(s) could be output via the instruction output unit. For example, the control module 100 is also equipped with a power supply
20 by which the central control unit can be energized to operate.

The constant pressure gas source 200 is configured to be air-tightly in fluid communication with the constant pressure fluid storage container 300 via a pipeline. The constant pressure gas source 200 can be a device well-known by a person skilled in the art which is configured to discharge a gas at a substantially constant pressure. For example, the device here can comprise an air compressor or can comprise a pressurized gas bottle or a pressurized gas tank. In case that the device is the pressurized gas bottle or the pressurized gas tank, a gas can be pressurized and stored in the bottle or tank in an amount sufficient to meet microfluidic pressure requirements. Moreover, the bottle or tank is provided with a gas outlet to which a constant pressure valve (not shown) is connected. The constant pressure valve is controllable by the control module 100 such that the gas can be discharged at a
30 substantially constant pressure through the gas outlet. For example, a gas inlet 310 is disposed in the constant pressure fluid storage container 300. The gas inlet 310 is configured to be air-tightly in fluid communication with the constant pressure gas source 200 (or with the constant pressure valve in case of the pressurized gas bottle or the pressurized gas tank) via a pipeline. Alternatively, the gas inlet 310 is configured to be air-tightly in fluid communication with the air compressor via a pipeline. A fluid to be discharged by the fluid pumping system is stored in the constant pressure fluid storage container 300. Therefore, the constant pressure fluid storage container 300 is provided with a fluid outlet 320 which is liquid-tightly connected to a pipeline which at least partially runs below a fluid

level in the constant pressure fluid storage container 300. In a preferred embodiment, the constant pressure fluid storage container 300 is configured such that the gas inlet 310 is above the fluid level. In this case, when the gas is supplied or discharged from the constant pressure gas source 200 at a given (substantially constant) pressure via the gas inlet 310 into the constant pressure fluid storage container 300, a specific internal gas pressure will be generated in a space, above the fluid level, within the constant pressure fluid storage container 300 such that under the action of the thus-generated internal gas pressure the fluid in the constant pressure fluid storage container 300 can be pressed or driven into the corresponding pipeline (liquid-tightly connected to the fluid outlet 320) via an entrance of the pipeline which is below the fluid level and then be discharged out through the fluid outlet 320 at a substantially constant pressure and substantially stable flow rate. The constant pressure gas source 200 is configured to selectively supply or discharge the pressurized gas under the control of the control module 100. Therefore, the fluid outlet 320 or the pipeline connected to the fluid outlet 320 can be regarded as a fluid outlet of the fluid pumping system according to the preset application.

The fluid refilling module 500 generally comprises a fluid refilling tank and a fluid refilling pump. The fluid refilling tank is configured such that it can be selectively opened or closed and thus a fluid to be discharged by the fluid pumping system can be selectively refilled into the fluid refilling tank. The fluid refilling pump can be a peristaltic pump, a gear pump, a plunger pump, or any suitable mechanical pump. Moreover, the fluid refilling pump is configured such that a fluid can be supplied by it at a substantially constant or non-constant pressure. The fluid refilling tank is configured to be in fluid communication with the constant pressure fluid storage container 300 via the fluid refilling tank and a pipeline. Therefore, the fluid refilling module 500 or its fluid refilling pump can be configured to operate under control of the control module 100 to selectively pump the fluid in the fluid refilling tank into the constant pressure fluid storage container 300.

The detection module 400 is configured to detect the fluid level, a fluid temperature and a fluid pressure in the constant pressure fluid storage container 300 and the internal gas pressure in the constant pressure fluid storage container 300 and/or to monitor a fluid level, a fluid temperature and a fluid pressure in the fluid refilling tank of the fluid refilling module 500 and an internal gas pressure in the fluid refilling tank of the fluid refilling module 500 or the like. The detection module 400 is connected to the data input unit of the control module 100 such that data detected or monitored by the detection module 400 can be input into the control module via the data input unit. As an example, the detection module 400 can comprise a level gauge. The level gauge can be taken in any suitable form. For example, the level gauge can be a ball-float type level gauge, a radar level gauge, a contact level gauge or any other suitable level gauge which is linked to a circuit capable of generating an electrical signal. In an embodiment of the present application, the level gauge is configured to operate in a mechanically-based, electrically-based, or optically-based manner or in a manner of AI (Artificial Intelligence) vision. The level gauge can be configured to detect the fluid level in the

constant pressure fluid storage container 300 and/or the fluid refilling tank to generate and provide corresponding detected signals to the control module 100. As an example, the detection module 400 also comprises a fluid pressure sensor. For example, the fluid pressure sensor can be disposed to the constant pressure fluid storage container 300 and/or the fluid refilling tank and/or to the pipelines connected to the fluid outlets thereof to detect or monitor the fluid pressure in the constant pressure fluid storage container 300 and/or the fluid refilling tank.

10 In an embodiment of the present application, the fluid refilling tank of the fluid refilling module 500 is configured to be in fluid communication with a fluid refilling port 330 of the constant pressure fluid refilling container 300. Under control of the control module 100, the fluid in the fluid refilling tank can be selectively supplied into the constant pressure fluid storage container 300. According to the present application, supplying the fluid into the constant pressure fluid storage container 300 will not affect discharging the fluid, which was already in the constant pressure fluid storage container 300, out of the fluid outlet 320 under the internal gas pressure of the constant pressure fluid storage container.

Fig. 2 is a view schematically illustrating an example of the fluid pumping system according to the embodiment of the present application. In the illustrated example, modules or constituent parts of the fluid pumping system are represented by symbolic symbols respectively. It should be understood by a person skilled in the art that the modules or their constituent parts represented by the symbolic symbols can be embodied in any suitable forms as long as corresponding functions can be achieved.

20 As shown, the control module 100 is electrically connected to the fluid refilling pump 510 of the fluid refilling module 500 by a flat cable to control operation of the fluid refilling pump 510. Furthermore, in the illustrated example, the detection module 400 is shown to include a level gauge 410. For example, the level gauge 410 can be electrically connected to the control module 100 via an electrically conductive wire. In an alternative embodiment, the control module 100 can be electrically connected to the level gauge 410 or the fluid refilling pump 510 or other constituent part(s) of the fluid pumping system in a wireless manner (such as via Bluetooth, WiFi, 5G communication network or the like) to receive data therefrom or send control instructions thereto. The level gauge 410 is configured to detect or monitor the fluid level in the constant pressure fluid storage container 300. In the illustrated example, the constant pressure fluid storage container 300 comprises a container
30 body and a container top. The gas inlet 310, the fluid outlet 320 and the fluid refilling port 330 are disposed in the container top. The gas inlet 310 is air-tightly connected to the constant pressure gas source 200 by a pipeline 11. In the context of the present application, the pipeline or any mentioned pipeline can refer to a hose.

Furthermore, a pipeline 10 is configured to be air-tightly inserted through the fluid outlet 320, and the pipeline 10 is configured to extend at least partially below the fluid level in the constant pressure fluid storage container 300. In an alternative embodiment, a joint having a hollow interior is air-tightly

installed through the container top at the fluid outlet 320; and the pipeline 10 can comprise two pipeline sections, one of which is air-tightly connected to the joint outside the constant pressure fluid storage container 300, and the other of which is air-tightly connected to the joint within the constant pressure fluid storage container 300. For example, an opening of the pipeline 10 within the constant pressure fluid storage container 300 can be located at a container bottom of the constant pressure fluid storage container 300 opposite to the container top. Especially, the opening of the pipeline 10 is normally located below the fluid level within the constant pressure fluid storage container 300. A pipeline 9 disposed between the fluid refilling pump 510 and the constant pressure fluid storage container 300 can be configured to be air-tightly inserted through the fluid refilling port 330 in a way similar to the pipeline 10 or alternatively to be disposed at the fluid refilling port 330 via a similar joint. In the illustrated embodiment, the fluid refilling tank 520 of the fluid refilling module 500 can be in the form of a cylinder body having a top opening through which a fluid can be refilled into the fluid refilling tank 520 whenever necessary. In an alternative embodiment, a cover can be releasably arranged onto the top opening of the cylinder body. A fluid inlet of the fluid refilling pump 510 is in fluid communication with the fluid refilling tank 520 via a pipeline 8 and a fluid outlet of the fluid refilling pump 510 is in fluid communication with the constant pressure fluid storage container 300 via the pipeline 9.

In an embodiment, a maximum fluid level value, a minimum fluid level value, and a fluid level value for pump normal operation between the maximum fluid level value and the minimum fluid level value can be prescribed for the constant pressure fluid storage container 300, and the fluid level of the constant pressure fluid storage container 300 can be detected by the level gauge 410 to compare a detected value of the fluid value with the prescribed values respectively. In the context of the present application, the maximum fluid level (value) of the constant pressure fluid storage container 300 means that a gas space can be sufficiently left between the fluid level and the container top such that the pressure of the gas supplied via the gas inlet 310 into the gas space can be used to press or drive the fluid out through the fluid outlet of the fluid pumping system.

Fig. 3 is a flow chart schematically illustrating a method for controlling the fluid pumping system according to an embodiment of the present application. It should be noted here that the method or its steps as described can be written as computer program(s) which can be stored in a memory of the control module 100 and invoked and executed whenever necessary. In an embodiment of the present application, the fluid refilling pump 510 is configured to operate in two modes. When the fluid refilling pump 510 operates in a first one of the two modes, the fluid can be supplied from the fluid refilling tank 520 to the constant pressure fluid storage container 300 via the pipelines 8 and 9 at a non-zero first flow rate. When the fluid refilling pump 510 operates in a second one of the two modes, the fluid can be supplied from the fluid refilling tank 520 to the constant pressure fluid storage container 300 via the pipelines 8 and 9 at a non-zero second flow rate which is greater than the first flow rate.

At step S10, under control of the control module 100, the fluid pumping system begins to operate such that the constant pressure gas source 200 can drive the fluid in the constant pressure fluid storage container 300 to be discharged through the pipeline 10. In the meanwhile, the fluid refilling pump 510 can be activated to operate in the first mode such that the fluid can be supplied or refilled from the fluid refilling tank 520 into the constant pressure fluid storage container 300.

At step S20, the fluid level of the constant pressure fluid storage container 300 can be detected by the detection module 400. For example, detection of the fluid level can be implemented at a given time interval such as 1 second, 2 seconds, 1 minute or less or more. At step S30, it is judged whether a detected value of the fluid level of the constant pressure fluid storage container 300 is greater than the prescribed maximum fluid level value. Every time when the value of the fluid level of the constant pressure fluid storage container 300 has been detected, it is judged whether the detected value of the fluid level is greater than the prescribed maximum fluid level value. If the detected value of the fluid level is judged to be greater than the prescribed fluid level value, the method goes to step S40; otherwise, the method goes to step S50. At step S40, the fluid refilling pump 510 is deactivated such that no fluid will be supplied or refilled from the fluid refilling tank 520 to the constant pressure fluid storage container 300. At step S50, it is judged whether the detected value of the fluid level is greater than the prescribed fluid level value for pump normal operation. If the detected value of the fluid level is greater than the prescribed fluid level value for pump normal operation, the method goes to step S60; otherwise the method goes to step S70. At step S60, the fluid refilling pump 510 is controlled to operate in the first mode. Then, the method goes from step S60 to step S70. At step S70, it is judged whether the detected value of the fluid level is greater than the prescribed minimum fluid level value. If the detected value of the fluid level has been greater than the prescribed minimum fluid level value, the method goes to step S60; otherwise the method goes to step S80. At step S80, the fluid refilling pump 510 is controlled to operate in the second mode such that a fluid can be rapidly supplied or refilled from the fluid refilling tank 520 to the constant pressure fluid storage container 300 to ensure that the fluid can be sufficiently and continuously discharged from the constant pressure fluid storage container 300.

In an embodiment of the present application, the openings of the pipelines 9 and 10 in the constant pressure fluid storage container 300 are always below a fluid level corresponding to the minimum fluid level value. Furthermore, the fluid is supplied through the pipeline 9 at a pressure which can overcome the internal gas pressure of the constant pressure fluid storage container 300 such that the fluid can be refilled therein and the pressure of the fluid will not affect discharging the fluid via the pipeline 10 under the internal gas pressure.

Fig. 4 is a view schematically illustrating internal gas pressure variation of the constant pressure fluid storage container of the fluid pumping system during a fluid refilling process thereof; and Fig. 5 is a view schematically illustrating flow rate variation occurring during a fluid pumping-out process of the fluid pumping system. It can be seen that although the internal gas pressure of the constant pressure

fluid storage container 300 might has fluctuation during the fluid refilling process of the fluid refilling pump 510, the actually discharged fluid from the container is always kept at a substantially constant / stable flow rate (no significant flow rate fluctuation) and the fluid can be discharged for a relative long time period.

According to the method of the embodiment of the present application, the fluid can be discharged continuously out of the constant pressure fluid storage container 300 to avoid that the entire system has to be shut down (like did in the prior art) in order to suspend the gas pressure generated from the constant pressure gas source 200 and thus refill the fluid into the constant pressure fluid storage container 300. According to the present application, the fluid can be discharged continuously out of
10 the constant pressure fluid storage container 300 in that refilling the fluid into the constant pressure fluid storage container 300 and discharging the fluid out of the constant pressure fluid container 300 can be implemented without affecting each other.

According to an embodiment of the present application, the internal gas pressure of the constant pressure fluid storage container 300 is controlled to mainly achieve gas pressure stabilization therein to ensure that the fluid can be pressed or driven out of the constant pressure fluid storage container 300 via the pipeline 10 substantially at a stable flow rate. The constant pressure fluid storage container 300 is configured such that the gas inlet 310, the fluid outlet 320 and the fluid refilling port 330 are air-tightly and/or fluid-tightly sealed such that the sealing position(s) can withstand the internal gas pressure sufficient to press or drive the fluid out of the constant pressure fluid storage
20 container 300. The constant pressure fluid storage container 300 and/or the fluid refilling tank 520 can be substantially cylinder-shaped or in the form of any other suitable geometry.

In an alternative embodiment, the detection module 400 can be configured to detect the fluid level in the fluid refilling tank 520 such that when a detected value of the fluid level of the fluid refilling tank 520 is less than a given value, a visual message can be displayed on a (not-shown) display screen by the control module 100 and/or an audible alarm can be sounded by a buzzer to alert a user to refill a fluid into the fluid refilling tank 520. For example, refilling the fluid into the fluid refilling tank 520 can be manually implemented by the user who can directly refill the fluid into the fluid refilling tank 520.

Although some specific embodiments of the present application have been described, they are given
30 here for illustrative purposes only and cannot be deemed to constrain the claimed scope of the present application. Furthermore, it should be understood by a person skilled in the art that the embodiments and/or examples described here can be combined with each other. Without departing from the spirit and scope of the present application, various modifications, replacements and alternations can be thought out.

Claims

1. A fluid pumping system, comprising:

a constant pressure gas source (200);

a constant pressure fluid storage container (300); and

a fluid refilling module (500), wherein the constant pressure gas source (200) is configured to be in fluid communication with the constant pressure storage container (300) such that a pressurized gas can be supplied from the constant pressure gas source (200) into the constant pressure fluid storage container (300) to drive a fluid within the constant pressure fluid storage container (300) out of a fluid outlet (320) of the constant pressure fluid storage container (300), and the fluid refilling module (500) is configured to be in fluid communication with the constant pressure fluid storage container (300) independent of the constant pressure gas source (200) and the fluid outlet (320) such that a fluid can be selectively supplied into the constant pressure storage container (300) without affecting the fluid being driven by the pressurized gas out of the fluid outlet (320) of the constant pressure fluid storage container (300).

2. The fluid pumping system according to claim 1, wherein the fluid refilling module (510) comprises a fluid refilling pump (510) and a fluid refilling tank (520), and the fluid refilling tank (520) is configured to be in fluid communication with the constant pressure fluid storage container (300) via a pipeline (8, 9) in which the fluid refilling pump (510) is connected in series such that when the fluid refilling pump (510) is being operated the fluid can be sucked from the fluid refilling tank (520) into the constant pressure container (300) via the pipeline (8, 9).

3. The fluid pumping system according to claim 1 or 2, further comprising:

a detection module (400) including a level gauge to detect a fluid level in the constant pressure fluid storage container (300).

4. The fluid pumping system according to claim 3, wherein the fluid refilling module (500) is prevented from supplying the fluid into the constant pressure fluid storage container (300) when a detected value of the fluid level is greater than a prescribed maximum fluid level value.

5. The fluid pumping system according to claim 4, wherein when the detected value of the fluid level is not greater than the prescribed maximum fluid level value, the fluid refilling pump (510) of the

fluid refilling module (500) is selectively switchable between a first mode, in which first mode the fluid can be supplied by the fluid refilling pump (510) from the fluid refilling tank (520) at a non-zero first flow rate, and a second mode in which second mode the fluid can be supplied by the fluid refilling pump (510) from the fluid refilling tank (520) at a non-zero second flow rate greater than the non-zero first flow rate.

10 6. The fluid pumping system according to claim 5, wherein the fluid refilling pump (510) is configured to operate in the first mode when the detected value of the fluid level is less than a prescribed fluid level value for pump normal operation and greater than a prescribed minimum fluid level value; or the fluid refilling pump (510) is configured to operate in the second mode when the detected value of the fluid level is not greater than the prescribed minimum fluid level value.

7. The fluid pumping system according to claim 6, wherein the constant pressure fluid storage container (300) is provided with a gas inlet (310), a fluid outlet (320) and a fluid refilling port (330) which are independent of each other.

20 8. The fluid pumping system according to claim 7, wherein the constant pressure gas source (200) is configured to be air-tightly connected to the gas inlet (310) of the constant pressure fluid storage container (300) via a second pipeline (11) such that the pressurized gas can be supplied from the constant pressure gas source (200) into the constant pressure fluid storage container (300); and a third pipeline (10) is air-tightly connected to the fluid outlet (320) such that the fluid can be driven out of the constant pressure fluid storage container (300) under action of the pressurized gas.

9. The fluid pumping system according to claim 8, wherein the third pipeline (10) and/or the pipeline (8, 9) connected to the fluid refilling pump (510) has a pipeline section in the constant pressure container (300), and the pipeline section has an opening which extends below the fluid level in the constant pressure fluid storage container (300).

30 10. The fluid pumping system according to claim 9, wherein the constant pressure (200) is configured such that after the pressurized gas is supplied into the constant pressure fluid storage container (300) the fluid can be discharged out of the constant pressure fluid storage container (300) via the third pipeline (10) at a substantially stable flow rate.