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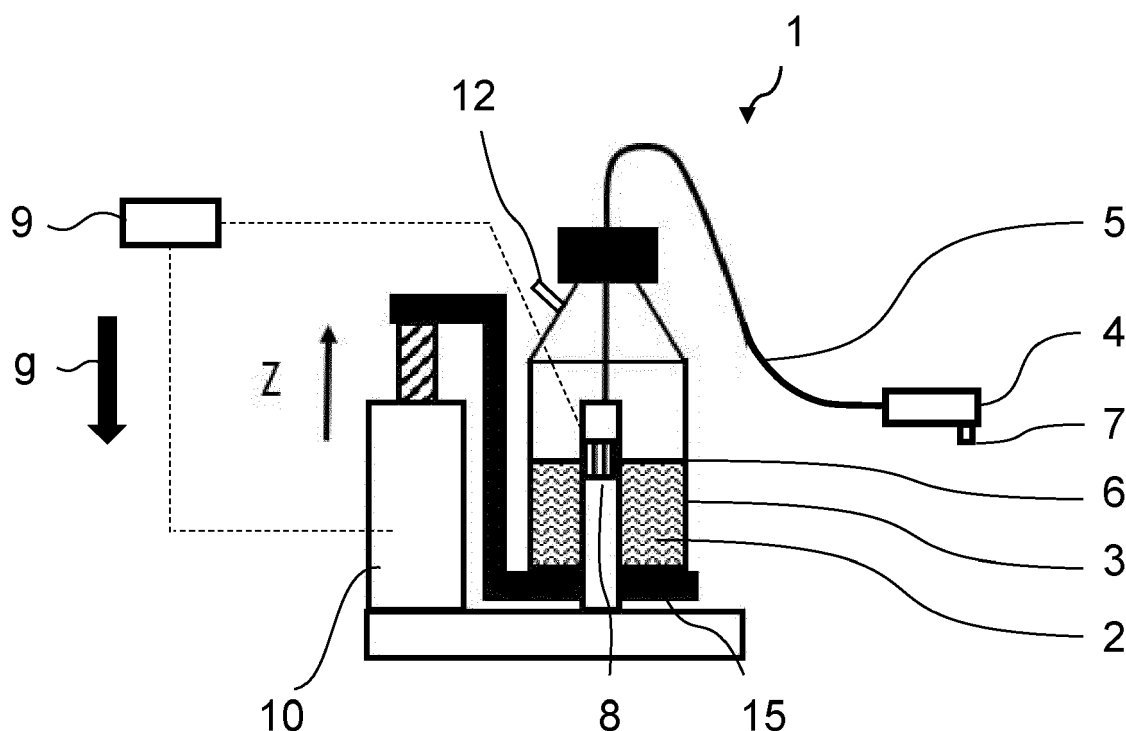
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(54) **METHOD AND DISPENSER APPARATUS FOR DISPENSING A LIQUID OUT OF A VESSEL**

(57) A method of dispensing a liquid 2 comprises the steps of providing a liquid vessel 3 including the liquid 2 to be dispensed, providing a liquid dispenser 4 being fluidically connected via a tube 5 with the liquid vessel 3, supplying the liquid 2 from the liquid vessel 3 to the liquid dispenser 4 wherein a hydrostatical working pressure is

applied to the liquid 2, and dispensing the liquid 2 with the liquid dispenser 4, wherein the hydrostatical working pressure is controlled by adjusting a liquid level 6 in the liquid vessel 3. Furthermore, a dispenser apparatus 1 for dispensing a liquid 2 is described.



Description

[0001] The invention relates to a method and to a dispenser apparatus for dispensing a liquid out of a vessel. Applications of the invention are available in particular in the fields of biochemistry, biology, chemistry and medicine, e. g. for handling liquid biological samples.

[0002] Dispensing liquids, in particular liquid droplets, by employing liquid dispensers is generally known. Liquid dispensers are used in a variety of applications, e. g. for depositing droplet-shaped samples on a substrate. Automation of dispensing liquids is often needed, in particular in high throughput applications. However, available techniques often require a continuous monitoring by an operator to assure an incident-free workflow. This problem can be avoided by dividing a workflow into automated and non-automated sub-processes. However, dividing a workflow results in higher costs as a human operator is needed for watching the process and in a lower productivity resulting from longer production cycles. Furthermore, operators are likely to make mistakes or they might not watch the process as closely as they should. Quality issues of the product can be a direct consequence.

[0003] Handling and especially dispensing of liquids, e.g. in a laboratory environment, are required to fulfill high level standards in terms of precise and reproducible setting and measuring of liquid volumes to be dispensed. In particular, when small volumes of a liquid are to be handled, small changes in volume can have a relatively high impact on the usability of a sample due to unmet volume constraints. Thus, further limitations of conventional dispensing techniques may result from insufficient control of liquid volumes transferred with the dispenser to a target.

[0004] A particular problem occurring with the operation of a dispenser, like a piezoelectric or other dispenser, relates to the pressure inside the dispenser. As an example, droplets are expelled from the piezoelectric dispenser by pressure pulses created by a piezoelectric drive unit. For a stabile operation, the liquid in the dispenser can be subjected to a reduced pressure, which is adjusted such that the liquid is able to leave the dispenser by the effect of the pressure pulses only, i. e. it does not drop out of the dispenser without a pressure pulse. The reduced pressure typically can be adjusted by coupling the dispenser with a vessel containing the liquid to be dispensed. The dispenser and the vessel provide so-called communicating vessels. The liquid in the vessel creates a hydrostatic pressure, which provides the reduced pressure in the dispenser.

[0005] Conventional techniques known from laboratory practice do not provide measures for adjusting the pressure via the hydrostatic pressure or they have limitations in terms of automation of monitoring and adjusting the hydrostatic pressure created in the vessel and a precise adjustment of the reduced pressure in the dispenser.

[0006] It is an objective of the invention to provide an improved method and/or an improved dispenser appa-

ratus for dispensing a liquid, with which the disadvantages of conventional techniques can be avoided. In particular, it is an objective of the invention to provide dispensing liquids with improved precision and/or improved reproducibility and/or increased reliability. Furthermore, dispensing liquids is to be provided with improved capability of automation.

[0007] This objective is achieved by the method and/or the dispenser apparatus comprising the features of the independent claims. Preferred embodiments and applications of the invention are defined in the dependent claims and in the description, in particular with reference to the figures.

[0008] According to a first general aspect of the invention, the above objective is achieved by a method for dispensing a liquid, comprising the steps of providing a liquid vessel (or: liquid containing vessel) including the liquid to be dispensed, providing a liquid dispenser being fluidically connected via a tube with the liquid vessel, supplying the liquid from the liquid vessel to the liquid dispenser wherein a hydrostatical working pressure is applied to the liquid, and dispensing the liquid with the liquid dispenser. The liquid vessel and liquid dispenser are connected as communicating vessels. According to the invention, the hydrostatical working pressure is controlled by adjusting a liquid level of the liquid in the liquid vessel. Preferably, the hydrostatical working pressure is adjusted during operation of the liquid dispenser, e. g. continuously during the dispensing operation or intermittently between dispensing single droplets or repeatedly between phases of dispensing operation.

[0009] According to second general aspect of the invention, the above objective is achieved by a dispenser apparatus being configured for dispensing a liquid. The dispenser apparatus comprises a liquid vessel containing the liquid to be dispensed, a liquid dispenser being fluidically connected via a tube with the liquid vessel and being arranged for dispensing the liquid, wherein the tube is arranged for supplying the liquid from the liquid vessel to the liquid dispenser, and wherein a hydrostatical working pressure is applied to the liquid. According to the invention, a control device is arranged for controlling the hydrostatical working pressure by adjusting a liquid level of the liquid in the liquid vessel. The control device may comprise e. g. a computer unit. Preferably, the dispenser apparatus according to the second general aspect of the invention or an embodiment thereof is configured for implementing the method for dispensing a liquid according to the first general aspect of the invention or an embodiment thereof.

[0010] In terms of the inventive method, the step of providing the liquid vessel may comprise providing the vessel (or: container) including the liquid. Alternatively, the liquid vessel may be provided in an empty state, i. e. without the liquid to be dispensed, and the liquid to be dispensed is added just before coupling the liquid dispenser with the liquid vessel. The liquid vessel may have an open connection to a surrounding atmosphere, or it

may be closed relative to the surrounding atmosphere. The open liquid vessel has an advantage as no sub-pressure or vacuum can be established when liquid is drawn from the liquid vessel by the dispensing operation. The closed liquid vessel has an advantage in terms of protecting the liquid against unintended influences from the surrounding.

[0011] The liquid vessel can be at least partially made of a transparent material, thus allowing an optical, in particular visual, monitoring of the liquid in the vessel. Preferably, the liquid vessel has at least one transparent wall section. The liquid vessel can be completely transparent. The liquid vessel can be made of plastic, glass, metal or a combination thereof. The transparency offers the advantage, that an optical sensor can detect a surface level from the outside of the liquid vessel. Furthermore, a person can monitor a height of the liquid in the liquid vessel.

[0012] The liquid vessel further can be provided with a temperature setting element, that cools or heats the liquid vessel and the liquid included therein to a certain temperature. Optionally, the liquid vessel can be provided with a venting element that allows to equalize a pressure inside the liquid vessel with a pressure outside the liquid vessel. With a further variant, the liquid vessel, in particular a lid section thereof, can comprise at least one opening accommodating a tube to extract liquid and/or fill in liquid and/or at least one opening being arranged for manually filling liquid into the liquid vessel. The liquid vessel furthermore may comprise means to fixedly attach the liquid vessel to a carrier, e.g. a platform.

[0013] With the step of providing the liquid dispenser fluidically connected via a tube with the liquid vessel, the liquid dispenser is brought in fluidic contact to the liquid within the liquid vessel. One end of the tube or an opening of the tube thus may be in contact with at least a surface of the liquid within the liquid vessel or beneath the liquid surface, and the other end of the tube or an opening of the tube may be in contact with a liquid reservoir within the liquid dispenser. The tube is arranged such that there is an uninterrupted connection of the liquid between the liquid vessel and the liquid dispenser, in particular the liquid reservoir therein and a dispensing opening (output opening). Preferably, the tube may be arranged in such a way, that an opening of the tube within the liquid vessel is close to a lowermost area or a bottom region of the liquid vessel. This offers the advantage, that a continuous fluidic connection between the liquid within the liquid vessel and the liquid dispenser is uninterruptedly established even when the liquid level in the liquid vessel changes.

[0014] The step of supplying the liquid from the liquid vessel to the liquid dispenser wherein a hydrostatical working pressure is applied to the liquid preferably means, that the hydrostatical working pressure alone is sufficient to supply the liquid to the dispenser apparatus. This offers the advantage that no other device, like a pump or the like is necessary for a deliverance of the liquid.

[0015] Preferably, the hydrostatical working pressure

may be created by different relative heights of a liquid surface in the vessel and the dispensing opening of the liquid dispenser relative to a direction of gravitation. With the hydrostatical working pressure, a meniscus or a meniscus position of the liquid at the liquid dispenser, in particular at the dispensing opening thereof, may be controlled.

[0016] The term "liquid dispenser" generally refers to a device being configured for dispensing a liquid, preferably as liquid droplets. The dispenser apparatus may comprise e. g. a piezo-electrically driven dispenser apparatus (piezoelectric dispenser apparatus) or another type of dispenser apparatus creating the liquid droplets by the effect of pressure pulses.

[0017] The tube (conduit) connecting the liquid dispenser with the liquid vessel may be a flexible tube or a rigid tube or a combination of flexible and rigid sections connected to each other. The tube may be transparent or non-transparent, and in particular at least one section of the tube may be transparent. Transparency offers the advantage, that a liquid flow can be visually and/or optically monitored within the tube. Alternatively, the liquid flow within the tube can be monitored with a flow sensor, e. g. sensing a liquid flow on the basis of thermal differences in the liquid. The tube provides a continuous (i. e. uninterrupted) liquid connection between the liquid in the liquid vessel and the liquid in the liquid dispenser.

[0018] The tube is arranged for supplying the liquid from the liquid vessel to the liquid dispenser, wherein the hydrostatical working pressure is applied to the liquid. In particular depending on the employed liquid, the diameter of the tube may be chosen in such a way, that the liquid can flow through the tube in a substantially unobstructed manner. The tube may also have an inner surface that has a coating that reduces drag of the liquid when flowing through the tube.

[0019] The step of dispensing the liquid with the liquid dispenser comprises transferring a liquid portion, in particular a liquid droplet, of the liquid from the liquid dispenser to a target, like a substrate, a container or a reaction plate. The liquid is dispensed under the effect of the hydrostatical working pressure and/or a drive unit that drives the liquid out of the output opening of the liquid dispenser. The drive unit may be e. g. a piezo-electric drive unit, gas bubble drive unit or another drive unit type as available in the prior art.

[0020] If the liquid dispenser is operated with the combined effect of the hydrostatical working pressure and the drive unit, the dispensing of the liquid can be conducted by the drive unit and a liquid surface or a meniscus at the output opening can be precisely controlled by the hydrostatical working pressure before and after the dispensing operation in an advantageous manner. This even results in an improved adjustment of the volume of the liquid portion dispensed.

[0021] Optionally, a non-active dispenser apparatus, i. e. a dispenser apparatus without a drive unit can be employed, like e.g. a cannula. If the liquid is dispensed

exclusively by the hydrostatical working pressure, advantages in terms of a simple structure of the liquid dispenser can be obtained, which may be formed simply by a channel provided e. g. by the cannula and guiding the liquid from the tube end to the output opening, i. e. no drive unit is needed. Even the end of the tube connected with the liquid vessel can be used as the liquid dispenser.

[0022] According to a preferred embodiment of the invention, the liquid level in the liquid vessel can be adjusted to substantially match a level of a dispensing opening of the liquid dispenser. The expression "substantially match" comprises equal heights of the liquid level and the dispensing opening level or different heights of the levels with a relative height difference in the gravitation direction which is less than 1 cm, preferably less than 5 mm, or 2 mm or even less than 1 mm. This embodiment has the advantage, that a hydrostatical working pressure can be adjusted with high precision. With the relatively small height differences, a fine control of the hydrostatical working pressure is facilitated. Furthermore, an advantage in terms of using different types of liquid dispensers is obtained, that need different hydrostatical working pressures to function correctly. With a larger height difference, a higher hydrostatical working pressure and/or a higher flow rate may be established.

[0023] Adjusting the liquid level in the liquid vessel comprises setting the liquid level in vertical direction relative to the vertical position of liquid dispenser, in particular the dispensing opening thereof. The liquid level in the liquid vessel can be controlled to be higher than the vertical position of the liquid dispenser, in particular the dispensing opening thereof, so that a positive hydrostatical working pressure is created. The positive hydrostatical working pressure supports the dispensing operation. Alternatively, the liquid level in the liquid vessel can be controlled to be lower than the vertical position of the liquid dispenser, in particular the dispensing opening thereof, so that a negative hydrostatical working pressure is created. The negative hydrostatical working pressure assures that droplets do not leave the liquid dispenser in an unintended manner, e. g. by the action of gravity.

[0024] With a preferred embodiment of the invention, the liquid level in the liquid vessel can be adjusted by a vertical movement of the liquid vessel including the liquid therein and the liquid dispenser relative to each other, in particular of the liquid vessel relative to the position of the liquid dispenser. Accordingly, the liquid level is set by moving the liquid vessel in vertical direction. The speed of the vertical movement can be less than 1 mm/s, 2 mm/s, 5 mm/s or 1 cm/s. Furthermore, the vertical movement can comprise a higher speed mode, in which a fast movement can be conducted, e.g. equal to or more than 5 cm/s.

[0025] Small movement speeds offer the advantage, that precise liquid level adjustments are facilitated. The higher speed mode offers the advantage, that, e.g. in case of a required refill of the vessel or the like, a fast movement is possible thus saving time in a working proc-

ess. Also, the higher speed mode offers the advantage, that high flow rates of liquid are possible.

[0026] According to a further preferred embodiment of the invention, the liquid level in the liquid vessel can be adjusted by supplying liquid to the liquid vessel. Accordingly, the liquid level is set within the liquid vessel. The supply of liquid can be executed manually and/or with an automated process. In the case of a manual supply, a person refills the vessel with liquid or activates a mechanism that supplies liquid to the vessel. The liquid vessel may comprise an opening suitable for a manual liquid supply to the vessel. The manual liquid supply offers the advantage, that no further equipment for the liquid supply is necessary. Alternatively or additionally, the vessel may comprise an opening for an automated liquid supply. The automated liquid supply may comprise a pump device and a second tubing, that is arranged at the vessel in such a way, that the pump device is able to pump liquid through the second tubing into the vessel. Alternatively, a dispenser apparatus may be adapted for an automatic liquid supply. The automated liquid supply offers the advantage that no operator resources are needed and a continuous liquid dispensing process is secured.

[0027] The dispenser apparatus preferably comprises a liquid supply device, in particular a pump device, being arranged for supplying liquid to the liquid vessel and being coupled with the control device. The pump device is e. g. a piston pump, a gear pump, a screw pump or the like. The liquid supply device can be adapted for creating a relatively small volume flow of the liquid to the liquid vessel, e. g. a volume flow of equal to or less than 10 ml/min. Accordingly, advantages in terms of a high precision of adjusting the liquid level are obtained. Alternatively, the liquid supply device can be adapted for creating a relatively large volume flow of the liquid to the liquid vessel, e. g. a volume flow of equal to or more than 5 l/min, thus resulting in an advantageous manner in a high operation speed. Medium volume flows between the above limits can be created as well. The pump device can comprise more than one pump, preferably at least two different pumps. This offers the advantage, that a pump for small volume flows and a pump for high volume flows can be provided.

[0028] Advantageously, further steps of detecting the liquid level in the liquid vessel with a sensor device and adjusting the liquid level in the liquid vessel in dependency on at least one output signal of the sensor device can be provided according to another embodiment of the invention. The liquid vessel may be configured for fixedly or movably attaching at least one sensor device outside or inside of the liquid vessel. Detecting the liquid level may comprise sensing a quantitative vertical position of the liquid level and/or sensing whether the liquid level is within a predetermined range or not.

[0029] Adjusting the liquid level in the liquid vessel in dependency on at least one output signal of the sensor device may comprise presenting a signal to an operator, e.g. by displaying a pop-up on a computer display or

flashing a light or presenting an alarm sound, in dependency on the detected liquid level by the sensor device. The signal indicates to the operator that the liquid level needs to be adjusted, and the operator adjusts the liquid level manually.

[0030] Alternatively, the liquid level may be adjusted automatically. For example, the sensor device may provide the output signal to a control device, that is able to give a control signal to a pump device that pumps liquid into the vessel, thus adjusting the liquid level. In another example, the control device can provide the control signal to an actuator device in dependency on the at least one sensor device output signal that is able to move the vessels height. The control device may be able to process at least one output signal and also to provide at least one control signal to the pump or another actuator device.

[0031] In terms of device features, the dispenser apparatus can be provided with the sensor device being arranged for detecting the liquid level of the liquid in the liquid vessel and being coupled with the control device, wherein the control device is configured for adjusting the liquid level in the liquid vessel in dependency on at least one output signal of the sensor device. The sensor device may be configured for detecting the liquid level e. g. by optically sensing the liquid level with at least one optical sensor, by measuring a liquid pressure inside the liquid vessel and/or by electrically sensing the liquid level (e. g. by a resistance measurement). As a further alternative, the sensor device may detect a weight of the vessel that allows a calibration based calculation of the liquid level. Multiple sensor devices may be applied, that measure the liquid level preferably simultaneously. This offers the advantage, that the liquid level is measured more precisely and reliably.

[0032] Preferably, the sensor device comprises at least one sensor being arranged for detecting the liquid level from an outside of the liquid vessel. The sensor being operated from an outside of the liquid vessel may detect a surface and/or meniscus of the liquid inside the liquid vessel through a transparent section of the liquid vessel. The transparent section of the liquid vessel may be along a vertical axis of the liquid vessel, preferably along the whole length or height of the liquid vessel. This offers the advantage that the sensor device is capable of detecting a surface level of the liquid along the whole height of the liquid vessel, thus resulting in longer refill cycles.

[0033] Additionally or alternatively, the sensor device can comprise at least one sensor being arranged for detecting the liquid level from an inside of the liquid vessel. The sensor being operated from an inside of the liquid vessel can be provided in a way, that the sensor measures a liquid pressure at a certain point of the liquid vessel, preferably in a lower half or in particular at the bottom of the liquid vessel. The higher a surface level within the liquid vessel, the higher a detected pressure. The liquid pressure and the position of the sensor in the liquid vessel provides the information about the liquid level within the

liquid vessel.

[0034] With a further preferred embodiment of the invention, the dispenser apparatus is provided with a lifting device being arranged for setting a vertical position of the liquid vessel relative to the position of the liquid dispenser and being coupled with the control device. The direction of vertical movement may be upwards or downwards in relation to a gravitational field, or the direction of vertical movement comprises components, which are directed upwards and downwards in relation to the gravitation. Optional provision of a direction that is not exclusively vertical but also has horizontal components offers the advantage, that the vertical movement can be controlled even more precisely.

[0035] According to further preferred embodiments of the invention, the lifting device may be driven e. g. electrically, mechanically and/or hydraulically. Accordingly, the lifting device may comprise at least one of a linear piezo actuator, a hydraulic actuator and a pneumatic actuator. The lifting device can further comprise a linear axis or linear drive respectively, which can be driven by cable, belt, spindle or magnetically.

[0036] Features disclosed with reference to the dispenser apparatus and the embodiments thereof are also considered to be disclosed with reference to the inventive method and the embodiments thereof. The aspects and features according to the embodiments of the invention, in particular with regard to the design of the dispenser apparatus, thus also apply to the method and vice versa. The preferred embodiments and features of the invention described above are combinable with each other in any desired manner.

[0037] Further details and advantages of the invention are described below with reference to the accompanying figures, which show in:

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|-----------------|--|
| Figure 1 | features of preferred embodiments of a dispenser apparatus according to the invention; |
| Figures 2 and 3 | features of further preferred embodiments of a dispenser apparatus according to the invention; and |
| Figure 4 | a schematic workflow illustrating features of the method for dispensing a liquid according to the invention. |

[0038] Features of preferred embodiments of the invention are described in the following with reference to the configuration and method steps provided for the dispenser apparatus. Further details of fluid dispensing processing, e. g. the selection of materials and samples and further control or monitoring devices can be implemented as known per se from prior art, e. g. from available manual or machine-controlled dispenser apparatuses. The liquid dispensed with the inventive technique is e. g. water or a watery solution, e. g. including a sample, in

particular a biological sample, like at least one cell, at least one cell component or at least one biological macromolecule. The sample can be included in the liquid being arranged in the liquid vessel already. Alternatively, the sample can be added to the liquid via a sample supply device, like a sample reservoir connected via a controllable valve with the liquid dispenser. This optional separate sample supply device is not shown in the drawings. Exemplary reference is made to employing one or more optical sensor(s). The invention is not restricted to these embodiments, but alternatively can be implemented without a sensor or with another sensor type. Identical reference signs are used for the equal elements in the drawings.

[0039] Figure 1 shows a first embodiment of the dispenser apparatus 1, comprising a liquid vessel 3 and a liquid dispenser 4. The liquid vessel 3, like a bottle, is made of a transparent material, like glass or a clear plastic, and it contains liquid 2. A flexible tube 5 fluidically connects the liquid 2 in the liquid vessel 3 with the liquid dispenser 4. The liquid dispenser 4 can be e. g. a piezoelectric dispenser. Alternatively, a tube opening of the tube can provide the liquid dispenser 4. The liquid vessel 3 is arranged on a platform 15, which is connected to a lifting device 10. The liquid dispenser 4 is fastened to a fixed position of a support (not shown) and has a dispensing opening 7. The liquid vessel 3 has an open connection 12 to a surrounding atmosphere for pressure compensation purposes.

[0040] An optical sensor 8, like a CCD camera or a photodiode array, is arranged for detecting the liquid level 6 in the liquid vessel 3. In this embodiment, the optical sensor 8 is fixed to the ground or a carrier of the lifting device 10. The lifting device 10 and the optical sensor 8 are connected to a control device 9, like a computer unit, that receives output signals from the optical sensor 8 and that is arranged for controlling the lifting device 10. With the lifting device 10, the vertical position of the liquid vessel 3 can be changed by a movement with a direction component (indicated by arrow z in Figure 1) parallel to gravitation g.

[0041] In operation of the dispenser apparatus 1, the liquid 2 is supplied from the liquid vessel 3 to the liquid dispenser 4 and the liquid (2) is dispensed with the liquid dispenser 4 on a target (not shown). A hydrostatical working pressure is applied to the liquid 2 which is determined by the vertical position of the liquid level 6 in the liquid vessel 3. The liquid level 6 diminishes because of liquid being dispensed by the liquid dispenser 4. Alternatively or additionally, the liquid 2 could evaporate or a leakage in the liquid vessel could lead to a change of the liquid level 6.

[0042] The hydrostatical working pressure is controlled by matching the liquid level 6 in the liquid vessel 3 to the vertical position of the liquid dispenser 4, in particular the dispensing opening 7 thereof. To this end, the control device 9 analyzes the output signal of the optical sensor 8. Once the output signal of the optical sensor 8 indicates,

that the liquid level 6 is not in a predetermined range and deviates from the vertical position of the dispensing opening 7 more than a predefined limit, the control device 9 controls the lifting device 10 to lift up the platform 15 with the liquid vessel 3, until the liquid level 6 is in the predetermined range. Thus, moving up the liquid vessel 3 brings back the liquid level 6 to the predetermined range monitored by the optical sensor 8, resulting in the advantage that the hydrostatical working pressure is maintained at the dispensing opening 7 due to the control of the liquid level 6 in the liquid vessel 3 relative to the fixed position of the liquid dispenser 4. More accurate dispensing of liquid is made possible.

[0043] Figure 2 shows another embodiment of a dispenser apparatus 1. The setup is similar to the embodiment of Figure 1 and thus, only the differences will be pointed out. The lifting device (not shown) is behind the liquid vessel 3 in Figure 2 and thus only the platform 15 is visible. The dispenser apparatus 1 is provided with two optical sensors 8, that are arranged with a distance from the liquid vessel. Both optical sensors 8 detect the liquid level 6 of the liquid 2 in the liquid vessel 3 and provide their output signals to the control device 9. The control device 9 controls the lifting device to lift up the platform 15 with the liquid vessel 3 when at least one of the optical sensors 8 do not detect the liquid level 6. When two or even more sensors provide data and/or signals, the control device 9 can perform more sophisticated calculations to decide whether to trigger a lift up and/or a correction of the liquid level 6 or not. In particular, control of the lifting device can employ a machine-learning based analysis of the output signals of the at least two optical sensors 8.

[0044] Figure 3 shows another embodiment of a dispenser apparatus 1, which differs from the embodiments in Figures 1 and 2 in the way how the liquid level 6 in the liquid vessel 3 is adapted or maintained. In Figure 3, the liquid vessel 3 is fixedly arranged on a bottom or ground and an additional liquid reservoir 13 with liquid 2 is provided. A supply tube 14 connects the liquid reservoir 13 and the liquid vessel 3, wherein a liquid supply device 11 in the form of a gear pump is arranged in the supply tube 14. The control device 9 is connected to the optical sensor 8 and the liquid supply device 11. Once the liquid level 6 leaves the predetermined range, e. g. falls below a certain threshold, the liquid supply device 11 pumps liquid 2 into the liquid vessel 3 until the predetermined liquid level 6 is reached again and the output signal of the optical sensor 8 causes a stop of liquid supply. The embodiment of Figure 3 offers the advantage, that longer dispensing cycles can be executed because a higher volume of liquid 2 is available for the liquid level adjustment.

[0045] As an alternative to Figure 3, a combination of the embodiments of Figures 1 and 2 and Figure 3 can be applied, wherein the liquid reservoir 13 and the liquid supply device 11 are combined with a lifting device 10.

[0046] Figure 4 shows a schematic workflow diagram illustrating the method for dispensing a liquid 2 as ex-

cuted e. g. with the embodiments of Figures 1 to 3. Step S1 comprises providing the liquid vessel 3 including the liquid 2 to be dispensed. The liquid vessel 3 can be positioned on a platform 15 (Figures 1 or 2) or on the ground (Figure 3). Step S2 comprises providing the liquid dispenser 4 being fluidically connected via the tube 5 with the liquid vessel 3. Step S3 comprises supplying the liquid 2 from the liquid vessel 3 to the liquid dispenser 4 wherein a hydrostatical working pressure is applied to the liquid 2.

[0047] Step S4 comprises dispensing the liquid 2 with the liquid dispenser 4 wherein the hydrostatical working pressure is controlled by adjusting a liquid level 6 in the liquid vessel 3. Adjusting the liquid level 6 comprises moving the liquid vessel 3 to change a relative height of the liquid level 6 and/or add or extract liquid 2 to or from the liquid vessel 3.

[0048] The features of the invention disclosed in the above description, the drawings and the claims can be of significance individually, in combination or sub-combination for the implementation of the invention in its different embodiments.

Reference signs

[0049]

- 1 dispenser apparatus
- 2 liquid
- 3 liquid vessel
- 4 liquid dispenser
- 5 tube
- 6 liquid level
- 7 dispensing opening
- 8 sensor device
- 9 control device
- 10 lifting device
- 11 liquid supply device
- 12 open connection
- 13 liquid reservoir
- 14 supply tube
- 15 platform
- g direction of gravity

Claims

1. Method of dispensing a liquid (2), comprising the steps:

- providing (S1) a liquid vessel (3) including the liquid (2) to be dispensed,
- providing (S2) a liquid dispenser (4) being fluidically connected via a tube (5) with the liquid vessel (3),
- supplying (S3) the liquid (2) from the liquid vessel (3) to the liquid dispenser (4) wherein a hydrostatical working pressure is applied to the liquid (2), and

- dispensing (S4) the liquid (2) with the liquid dispenser (4),

characterized in that

- the hydrostatical working pressure is controlled by adjusting a liquid level (6) of the liquid in the liquid vessel (3).

2. Method according to claim 1, wherein

- the liquid level (6) in the liquid vessel (3) is adjusted to substantially match a level of a dispensing opening (7) of the liquid dispenser (4).

3. Method according to one of the foregoing claims, wherein

- the liquid level (6) in the liquid vessel (3) is adjusted by a vertical movement of the liquid vessel (3) relative to the position of the liquid dispenser.

4. Method according to one of the foregoing claims, wherein

- the liquid level (6) in the liquid vessel (3) is adjusted by supplying liquid (2) to the liquid vessel (3).

5. Method according to one of the foregoing claims, comprising the steps of

- detecting the liquid level (6) in the liquid vessel (3) with a sensor device (8), and
- adjusting the liquid level (6) in the liquid vessel (3) in dependency on at least one output signal of the sensor device (8).

6. Dispenser apparatus (1) being configured for dispensing a liquid (2), comprising:

- a liquid vessel (3) containing the liquid (2) to be dispensed,
- a liquid dispenser (4) being fluidically connected via a tube (5) with the liquid vessel (3) and being arranged for dispensing the liquid (2), wherein
- the tube (5) is arranged for supplying the liquid (2) from the liquid vessel (3) to the liquid dispenser (4), wherein a hydrostatical working pressure is applied to the liquid (2),

characterized by

- a control device (9) being arranged for controlling the hydrostatical working pressure by adjusting a liquid level (6) of the liquid in the liquid

vessel (3).

claims 6 to 12, wherein

7. Dispenser apparatus (1) according to claim 6, further comprising

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- a lifting device (10) being arranged for setting a vertical position of the liquid vessel (3) relative to the position of the liquid dispenser (4) and being coupled with the control device (9).

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8. Dispenser apparatus (1) according to claim 7, wherein

- the lifting device (10) comprises at least one of a linear piezo actuator, a hydraulic actuator and a pneumatic actuator.

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9. Dispenser apparatus (1) according to one of the claims 6 to 8, further comprising

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- a liquid supply device (11), in particular a pump device, being arranged for supplying liquid to the liquid vessel (3) and being coupled with the control device (9).

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10. Dispenser apparatus (1) according to one of the claims 6 to 9, further comprising

- a sensor device (8) being arranged for detecting the liquid level (6) of the liquid (2) in the liquid vessel (3) and being coupled with the control device (9), wherein

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- the control device (9) is configured for adjusting the liquid level (6) in the liquid vessel (3) in dependency on at least one output signal of the sensor device (8).

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11. Dispenser apparatus (1) according to claim 10, wherein the sensor device (8) comprises at least one of the features

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- the sensor device (8) comprises at least one sensor being arranged for detecting the liquid level (6) from an outside of the liquid vessel (3),
- the sensor device (8) comprises at least one sensor being arranged for detecting the liquid level (6) from an inside of the liquid vessel (3), and
- the sensor device (8) comprises at least one optical sensor.

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12. Dispenser apparatus (1) according to one of the claims 6 to 11, wherein

- the liquid vessel (3) has at least one transparent wall section.

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13. Dispenser apparatus (1) according to one of the

- the liquid vessel (3) has an open connection (12) with the surrounding atmosphere for pressure compensation purposes.

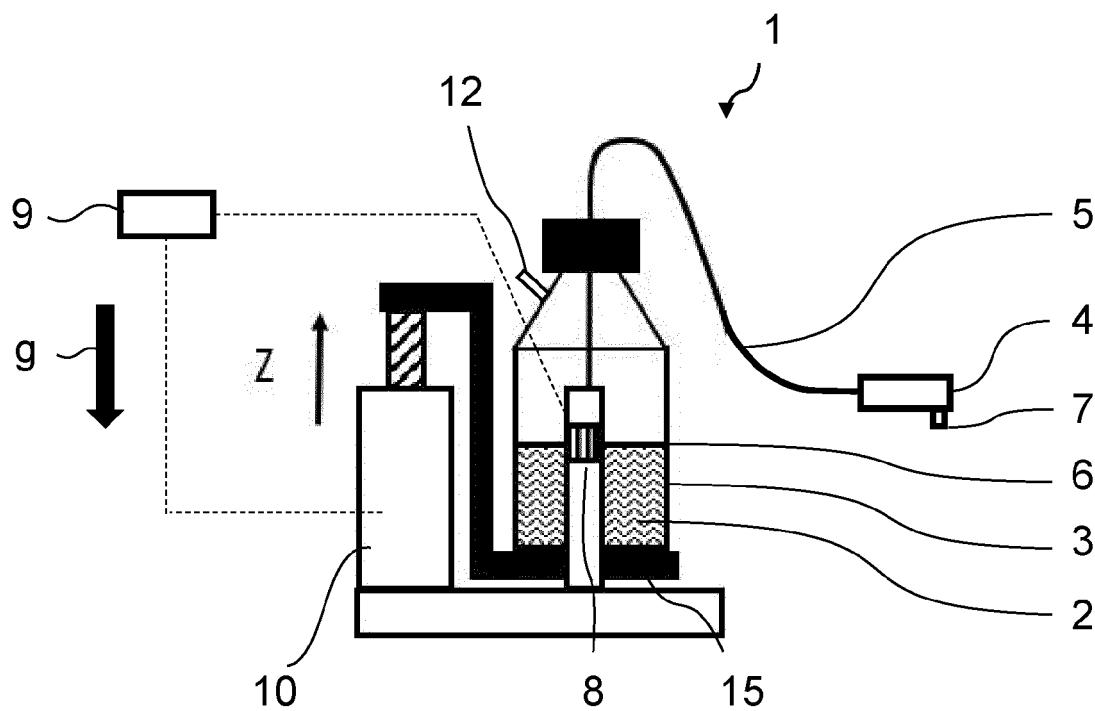


FIG. 1

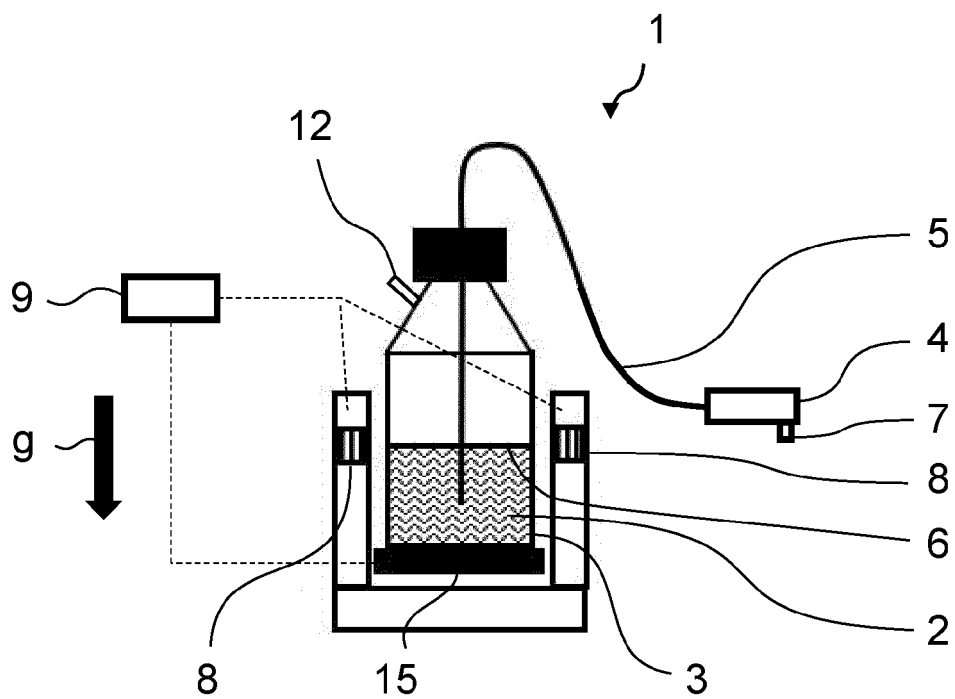


FIG. 2

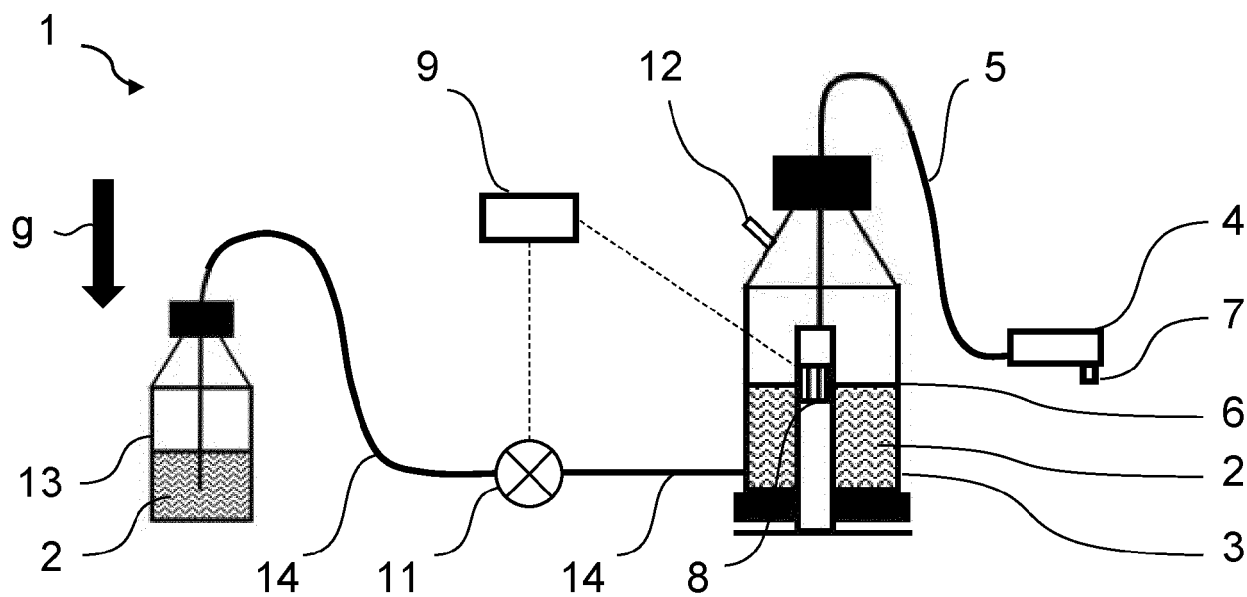


FIG. 3

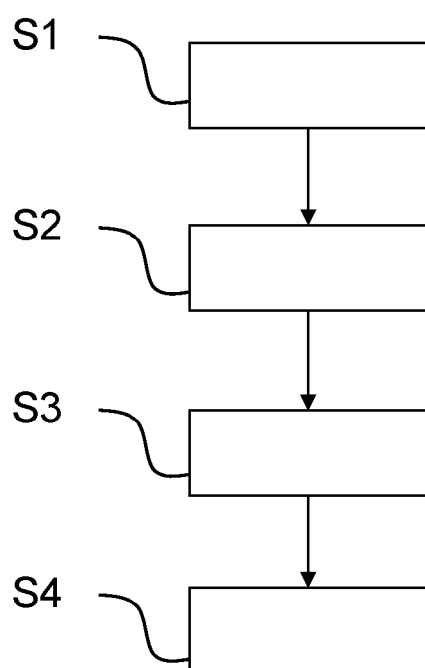


FIG. 4



EUROPEAN SEARCH REPORT

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			TECHNICAL FIELDS SEARCHED (IPC)
			B01L
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 20 May 2022	Examiner Ueberfeld, Jörn
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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