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(54) SYSTEM AND APPARATUS FOR CARBONATION OF A LIQUID

(57) The present invention refers to a system comprising a removable container (100) and an apparatus (1) for carbonation of a liquid contained in the container such as a home soda machine. Further, the present invention refers to an apparatus (1), for example the apparatus used with said system, for carbonation of a liquid contained in a removable container (100). The container (100) comprises a container height between a bottom (101) and an opening, and the apparatus (1) is configured to hold the container (100) and comprises: a pressure supply unit (4) for providing pressurized gas, and a tube (7) connected to the pressure supply unit (4), wherein the tube (7) has an inner diameter, and wherein the tube (7) is at least partially received via the opening within the container (100) when the container (100) is held in the apparatus (1). Carbonation of a liquid may be improved in that a nozzle head (8) is provided connected to the tube (7) and comprising at least one nozzle outlet (17) for supplying the gas to the liquid inside the container (100), wherein a diameter of the at least one nozzle outlet (17) is smaller than the inner diameter of the tube (7), and wherein when the container (100) is held in the apparatus (1), the nozzle head (8) is located within the third of the container height nearer to the bottom (101) of the container (100).

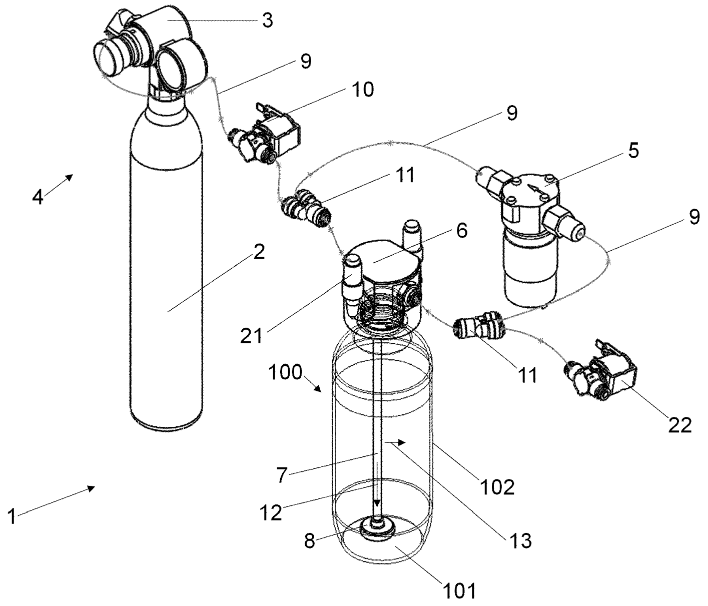

Fig. 1

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Description

[0001] The present invention refers to a system comprising a removable container and an apparatus for carbonation of a liquid contained in the container such as a home soda machine. Further, the present invention refers to an apparatus, for example the apparatus used with said system, for carbonation of a liquid contained in a removable container.

[0002] Many different systems and apparatuses for enriching gas in beverage liquids such as water are known on the market. The gas which is used to enrich the respective liquids is typically carbon dioxide (CO_2) which is introduced into a beverage container, usually a bottle, via a spout or opening of the container.

[0003] Such a system for carbonating liquids is known from WO 2016/181279 A1. This system has a canister with pressurized CO_2 gas, which is introduced into a bottle via a carbonation head and a tube. In order to carbonate the liquid, the bottle has to be previously filled, for example at a water tap, so that the liquid can be carbonated by the gas flowing into the liquid from the pressure supply unit and via the tube. Once the gas enrichment process is completed, the user receives a sparkling liquid ready for drinking.

[0004] However, the canister filled with pressurized gas has a limited filling volume, i.e., a limited amount of gas, which gas is reduced each time the system is operated to carbonate liquid. Accordingly, the canister has to be replaced at some point, which is time-consuming and cost intensive. Thus, increasing the efficiency of gas enrichment in the liquid allows for a prolonged use of the canister and reduces costs.

[0005] To increase the efficiency of carbon dioxide gas enrichment in a liquid, WO 2016/181279 A1 discloses a supply of carbon dioxide gas to a liquid in a pulsed manner, thereby reducing the gas consumption compared to a continuously supply of gas. WO 2014/197373 A1 discloses a method for carbonating a beverage in which carbonation cycles are applied to a liquid in a pulsed manner, however without teaching any improved efficiency regarding gas consumption.

[0006] However, the efficiency of conventional systems for carbonation of liquids is still in need of improvement. In this respect, the efficiency of the system is determined by the relation between the amount of gas being bound inside the liquid and the amount of gas supplied from a gas supply such as a canister into the liquid, i.e., the ratio between unbound and bound gas for a given amount of gas supplied into the liquid.

[0007] According to the aforementioned, the object of the present invention is to provide a system or apparatus for carbonation of a liquid, which has an increased efficiency in the enrichment of gas in a liquid inside a container compared to the systems known from the prior art.

[0008] This object is solved by a system according to claim 1 as well as by an apparatus according to claim 4.

[0009] A respective system may comprise a container and an apparatus for carbonation of a liquid inside the container. The container may be removed from the apparatus and may be used in a conventional manner, for example to fill liquid out of the container into a water glass. In addition, e.g. for carbonation of liquid contained in the container, it may be placed in the apparatus. The container of said system comprises a container height defined between a bottom and an opening, wherein the container height defines the distance between a container standing on its bottom to its opening, i.e., the distance between the surface on which the container is standing and the upper edge of the opening. The apparatus is configured to hold and said container. Further, the apparatus comprises a pressure supply unit for providing pressurized gas, and a tube with an inner diameter connected to said pressure supply unit and at least partially received via the opening within the container when the container is held in the apparatus.

[0010] The phrase "tube is at least partially received via the opening within the container" means that at least a part of the tube's length is received via the opening within the container. However, it is also possible that the tube is received in full, i.e. with it's full length, via the opening within the container.

[0011] The tube connected to the pressure supply unit may be rigid, flexible, or partially rigid and partially flexible. Preferably, said tube is rigid. When the container is held by the apparatus for carbonation, preferably, the tube is at least partially received via the opening located at the top of the container, which top is still in top position when held by the apparatus for carbonation. Furthermore, it is preferred that the tube is arranged in a head portion of the apparatus, so that the tube is received via the opening of the container when the container is held by the apparatus. In this regard, the tube extends within the container downwards in direction towards the bottom of the container.

[0012] The apparatus may further comprise a nozzle head connected to said tube. The length of the tube is, therefore, dimensioned such that the nozzle head connected to said tube is located in a position being within the third of the container height nearer to the bottom of the container. However, preferably the dimensions of the tube are chosen so that the nozzle head is not touching the bottom of the container when the container is held by the apparatus. Furthermore, it is further preferred that when the tube is received via the opening in the container, a cross-section of the tube is positioned centered relative to a cross-section of the opening, or at least substantially centered. More preferably, when the container is held by the apparatus, the cross-section of the tube is centered in relation to the bottom of the container.

[0013] As an alternative, the tube may be connected to a gas inlet device such as an inlet valve of the container, e.g. provided in the vicinity of its bottom. The nozzle head comprises at least one nozzle outlet for supplying the gas fed via the tube into the liquid inside said container. In this respect, a diameter of the at least one nozzle outlet is smaller than the inner diameter of the tube. According to an aspect of the present disclosure, when the container is held in the apparatus, the nozzle head is located within the third of the container height nearer to the bottom of the container. The phrase "nozzle head is located within the third of the container height nearer to the bottom of the container" means that the nozzle head may be located in any position from the third of the container height nearer to the bottom of the container to the bottom of the container. Preferably, the nozzle head is located within the quarter of the container height nearer to the bottom of the container. This results in supplying the gas into the liquid filled in the container such that the gas rises in the liquid substantially over the whole height of the liquid in the container which increases efficiency of gas enrichment. The same effect occurs when introducing gas via an inlet valve provided in the bottom region of the container.

[0014] The system and apparatus according to the present invention is suitable for use with any kind of removable container having an opening and capable of holding a liquid. Preferably, said removable container will have an upper portion having a smaller diameter than its lower portion, which upper portion may be termed as "neck" of the container. Said opening is typically located on top of said upper portion, i.e. the opening has a smaller diameter than the largest diameter of the container of the lower portion. Preferably, the container is a bottle or carafe, more preferably a bottle. Besides of said opening, the container may have additional openings. However, it is preferred that the container has only one opening, more preferably one opening located at its top. Preferably, the container is made of glass, plastic or stainless steel.

[0015] Preferably, the liquid which is to be carbonated inside the container is water, but any other drinkable liquid is also comprised by the invention. Typically, a water bottle having a maximum fill volume of about 1 liter is used as a container.

[0016] In the present invention, the term "carbonation" means enrichment of liquid with carbon dioxide (CO_2) gas.

[0017] The bottom of the container may either be flat or curved. The opening of the container may be sealed or closed by a removable cap or lid when used removed from the system or apparatus. For this purpose, the container or its opening respectively may be provided with an interface for attaching a lid, e.g. via a threaded interface.

[0018] The pressure supply unit may comprise a gas bottle or canister with a valve, for example a gas bottle with 70 bar CO_2 gas, wherein as soon as the valve is opened, gas flows out of the gas bottle. The pressure supply unit may further comprise a pressure regulator to set or determine the amount of gas being allowed to flow out of the gas bottle. The pressure regulator allows to suitably reduce the pressure of the gas in the gas bottle, which pressure is typically around 70 bar. Thereby, the pressure regulator allows to suitably set the pressure of the gas supplied for the gas bursts. Preferably, the pressure regulator provides supplied gas for the gas bursts at a maximum pressure of 8 bar, preferably a pressure between 2 bar and 6 bar, more preferably a pressure between 2.5 bar and 4.5 bar, most preferably a pressure between 2.8 bar and 3.2 bar. The valve and the pressure regulator may be opened and closed by an, e.g. electronic, control unit or manually by a user pushing a respective button of the apparatus. The gas may then flow from the gas bottle via respective fluid conduits into the tube that protrudes into the container via the opening, provided that the container is used with the apparatus for carbonation and is held by said apparatus. A head portion of the apparatus may be used to seal the container when being used with the apparatus. For this purpose, the container may, for example and as described before, be attached to the apparatus directly via coupling means at the opening of the container which engage with respective counterparts, for example at the head portion of the apparatus, or the container may be held indirectly, for example via a receptacle, in which the container is inserted, and which is coupled to the apparatus, for example by a bayonet coupling. The nozzle head being connected to the distal end of the tube, i.e., the end closest to the bottom of the container when the container is used with the apparatus, has at least one nozzle outlet, for discharging the gas flowing through the tube, into the container and more precisely into a liquid inside the container which is to be filled into the container, preferably beforehand. The liquid may be filled into the container beforehand, for example by a water tap, or may be filled into the container from a tank inside the apparatus. The liquid is then enriched with gas. This means the liquid is carbonated.

[0019] The apparatus may further comprise a respective user interface to allow the user to select the amount of gas to be supplied to the liquid, for example medium sparkling. Further, the apparatus may comprise sensor means determining or detecting a degree of carbonation, the end of an enrichment process or the like.

[0020] By making the diameter of the nozzle outlet smaller than the inner diameter of the tube, the gas flowing through the tube in the direction of the nozzle outlets can be accelerated due to the reduction in the cross-section of the respective gas conduits. This, together with the fact that the nozzle head is located within the lower third of the container, improves the distribution of the gas in the liquid, so that enrichment can take place much more efficient. This is due in particular to the fact that the gas rises up through the liquid, thereby increasing the probability of being bound in the liquid. Accordingly, the closer to the bottom of the container the gas supply takes place, the more efficient the enrichment process becomes, as the distance covered by the gas within the liquid can be increased.

[0021] Further, the reduction in cross-section at the at least one nozzle outlet compared to the inner diameter of the tube increases the surface area of the gas coming out of the nozzle outlets compared to gas coming directly out of the tube having a bigger diameter. Therefore, the enrichment is further improved. The efficiency of this system is, thus, highly increased compared to systems known from the prior art.

[0022] In order to build up pressure inside the removable container, the apparatus may be sealed by a head portion as already described above. Therefore, the tube may protrude into the liquid through this sealed head portion of the apparatus, when the container is used with the apparatus.

[0023] In order to further improve the efficiency of the system, in one embodiment, a suction pump may be provided in the apparatus, which may be releasably connected, for example via the head portion of the apparatus, to the opening of the container as well as to the tube when the container is held in the apparatus. For example, the suction pump is configured to extract gas from the container via the opening, when operated, e.g. from the space above the liquid level in the container. Further, the suction pump may be configured to reintroduce said gas succeed from the container back into the liquid inside the container via the nozzle head and the tube respectively. Thus, the suction pump is configured to suck out, i.e., extract, unbound gas which has been supplied via the nozzle head into the liquid and which is risen inside the liquid towards the opening above the liquid level. The circulation of the unbound gas, therefore, additionally increases the efficiency of the system.

[0024] In another embodiment, the apparatus of the system further comprises a control unit configured to operate the pressure supply unit in a pulsed manner with at least two gas bursts. This means, that the gas does not flow continuously from the pressure supply unit via the tube and the nozzle head into the liquid but is provided by separate shots (bursts), wherein between each burst there is a period without gas flowing from the pressure supply unit into the liquid. A gas supply in such a pulsed manner may be implemented, for example, by closing the valve on the pressure supply unit and only opening it during the gas bursts, wherein the control unit may operate the valve respectively. Supplying the gas into the liquid in a pulsed manner additionally increases the efficiency of enrichment of gas inside the liquid.

[0025] According to a further aspect of the present disclosure, the object of the present invention is solved by an apparatus. This apparatus may be used with the system described above so that the following features referring to an apparatus may also apply to the apparatus of said system. In this regard and according to one embodiment, the apparatus comprises a pressure supply unit for supplying pressurized gas to the liquid inside the container when the container is held in the apparatus and further comprises a suction pump releasably connected to the container when the container is held in the apparatus and a control unit configured to operate the pressure supply unit in a pulsed manner, e.g. with at least two gas bursts. Consequently, the apparatus may for example part of the system described above or may be a different apparatus, e.g. with or without a nozzle head.

[0026] Further, the control unit may be configured to operate the suction pump to extract gas from the container and to reintroduce said extracted gas into the liquid inside the container. Thus, the apparatus comprises the aforementioned advantages of reintroducing unbound gas in a circular manner by sucking of unbound gas from the container and reintroducing said gas.

[0027] In one embodiment of the present invention, the pressure supply unit is configured to supply gas into the liquid within the third of the container height nearer to the bottom of the container; and/or the pressure supply unit is configured to either supply gas into the liquid via an opening of the container via a tube and a nozzle head with at least one nozzle outlet or via a gas inlet device provided at a bottom of the container. The first option is, therefore, basically identical to the aforementioned gas supply via a tube and a nozzle head, wherein the tube and the nozzle head are introduced into the container, when a container is used with the apparatus. However, the gas may also be supplied via a gas inlet device provided at the bottom of the container. For this second option, the bottom of the container, for example with a corresponding valve mechanism, may be pressed onto said gas inlet device of the apparatus, providing a counterpart to the valve mechanism, thereby introducing gas into the container. Thus, independent of the alternative chosen to be implemented, the gas may be supplied into the liquid within the lower third of the container, which may lead to the positive effects described above.

[0028] In another embodiment, the nozzle head of the apparatus or the system is releasably attachable to the tube and/or the tube is releasable attachable to said apparatus, for example by respective threaded portions, clipping portions or the like. Consequently, a user may remove the nozzle head and/or the tube by unscrewing the respective component (tube or nozzle head) and, for example, replace it with another component if it is broken or in order to clean it. In particular, cleaning of the respective component can prevent microbiological growth and improve the quality of the liquid by preventing unintentional contamination. The nozzle head as well as the tube may also comprise different means for attachment, for example, the nozzle head may be screwed onto the tube, wherein the tube is clipped to the apparatus.

[0029] Further, in an alternative embodiment, the nozzle head may comprise at least two nozzle outlets, preferably at least six nozzle outlets, more preferably at least twelve nozzle outlets, most preferably twelve to twenty nozzle outlets. Each of the nozzle outlets may then still be smaller than the inner diameter of the tube. By using more nozzle outlets, for example up to twenty nozzle outlets, the distribution of the gas in the liquid can be further improved. In addition, the surface area of the gas can be further increased by dividing the gas flow inside the tube into multiple gas streams, which can further increase the probability of binding the gas into liquid.

[0030] In another embodiment, the nozzle outlets may be directed exactly or substantially in a direction of extension of the tube, i.e. downwards if the container stands upright in a conventional manner, and/or exactly or substantially perpendicular to the direction of extension of the tube, i.e. radially. This means that the nozzle outlets may face the bottom of the container and/or respective sidewalls of the container. However, the nozzle outlets are not supposed to be directed in the direction of the opening, i.e., in the direction in which the gas rises inside the liquid. By said arrangement of the nozzle outlets, the distribution of the gas in the liquid can be further improved.

[0031] Further, the diameter of each nozzle outlet may be in between 0.2 mm and 0.8 mm, preferably between 0.24 mm and 0.5 mm, more preferably between 0.28 mm and 0.4 mm. The size of the nozzle outlets increases the amount/number of fine bubbles of the gas inside the liquid. Due to the increased amount of fine bubbles, the contact surface between gas and liquid is increased. This in turn improves the distribution and/or dissolution of the gas inside the liquid, e.g. in case of gas in the form of CO_2, dissolution of CO_2 in a liquid in the form of water can be significantly improved.

[0032] In another embodiment, the nozzle head may comprise a cylindrical shape with a lateral surface, a bottom surface and a top surface, and wherein said nozzle outlets are arranged on the lateral surface and/or the bottom surface of the nozzle head. Accordingly, this shape of a nozzle head allows for the aforementioned distribution of gas towards the bottom as well as the sidewalls of the container.

[0033] Further, in one embodiment, the apparatus, for example the apparatus of the system, may comprise a relief valve operable e.g. with a maximum pressure of 8 to 11 bar, therefore controlling a maximum pressure level inside the removable container. Thus, as soon as the pressure inside the container rises above the respective pressure level, the relief valve opens. This makes it possible to work at low pressures in particular and at the same time prevent the container from breaking. Thus, once pressurized gas is introduced into the container, the pressure inside the container rises, for example up to 6 bar. Now, when gas is bound in the liquid, the pressure inside the container decreases. If the gas supply is operated in a pulsed manner, the pressure is increased again with each burst or shot. This means, for example, that the internal pressure of the container is 5 bar at the beginning, i.e., after a first burst, and then drops to 3 bar until the next burst occurs.

[0034] In another embodiment, for an apparatus operated in a pulsed manner, there is a period of 4 to 20 seconds (break time) between two consecutive gas bursts during which no gas burst is provided by the pressure supply unit. Preferably the aforementioned period (break time) is between 5 to 15 seconds, more preferably between 5 to 10 seconds. This period thus may define a time interval in which the suction pump is circulating the unbound gas, which rises above the liquid level and reintroduces this gas into the liquid. However, during this period no new gas is supplied from the pressure supply unit. Increasing the time period in which no new gas is supplied into the container additionally increases the efficiency of the system since there is more time for the supplied gas to be bound into the liquid.

[0035] Furthermore, in one embodiment, for the enrichment of gas in the removable container, the pressure supply unit is operated in a pulsed manner for 30 to 120 seconds, preferably for 30 to 90 seconds, more preferably for 30 to 60 seconds and/or the pressure supply unit is operated so that each gas burst lasts between 0.8 and 5 seconds, preferably between 0.8 and 3 seconds, more preferably between 0.8 and 2 seconds and most preferably between 0.9 and 1.2 seconds. Thus, the (gas) enrichment process, i.e., the carbonation, does not last more than 120 seconds. Therefore, after 120 seconds at the latest, the liquid inside the container is fully prepared. The aforementioned time periods are all controlled by the control unit, wherein the respective chosen times additionally increase the efficiency of bounding gas into the liquid.

[0036] According to a most preferred embodiment, the control unit is configured to operate the pressure supply unit in a pulsed manner for 30 to 60 seconds, wherein a period of 5 to 10 seconds between two consecutive gas bursts occurs during which no gas burst is provided by the pressure supply unit, and each gas burst lasts between 0.9 and 1.2 seconds. The time during which no gas burst occurs is also waited at after the last gas burst to allow the gas to be accumulated inside the liquid before an optional pressure compensation valve may be operated. However, this time period at the end may be chosen longer, for example 10 seconds. With the aforementioned time periods (which refer to test series 2 and 9 of table 1 below), a particularly high level of efficiency can be achieved while at the same time not taking too long to enrich the liquid. A gas enrichment process could look as follows: gas burst for 1 second; no gas bursts for 5 seconds; gas burst for 1 second; no gas bursts for 5 seconds; gas burst for 1 second; no gas bursts for 5 seconds; gas burst for 1 second; no gas bursts for 5 seconds; gas burst for 1 second; no gas bursts for 5 seconds; gas burst for 1 second; no gas bursts for 5 seconds; gas burst for 1 second; no gas bursts for 5 seconds; gas burst for 1 second; no gas bursts for 5 seconds; gas burst for 1 second; no gas bursts for 5 seconds; gas burst for 1 second; no gas burst for 5 seconds. The process would thus be completed after 60 seconds, during which the pressure supply unit was operated in a pulsed manner, and until the liquid would be fully prepared. The enrichment process would thus take 60 seconds with a total of 10 gas bursts.

[0037] The time during which the pressure supply unit is operated in a pulsed manner may also be called cycle time, wherein the time between two gas bursts during which no gas burst is provided may be called break time. Further, the time each gas burst lasts may be called burst time.

[0038] According to one embodiment, the control unit may operate the suction pump to suck continuously at least directly after the first gas burst. Thus, as soon as a first gas burst is supplied, the suction pump starts sucking. The circulation may then stop after the last burst or after a predetermined time period after the last burst. Therefore, the enrichment process of the liquid inside the container can be controlled fully automated.

[0039] The control unit may comprise a printed circuit board assembly (PCBA), e.g. with a micro-controller, and may be connected to a power supply. One or more operation modes may be stored on the PCBA, e.g. for different degrees of carbonation and/or different fill levels or amounts of liquid to be carbonated. The control unit may be connected with one or more sensors, e.g. for detecting gas pressure, fill level of the container or the like. In addition, a display unit, actuation means (user operation interface) and the like may be connected to or part of the control unit.

[0040] Therefore, the system as well as the apparatus both provide embodiments increasing efficiency of the enrichment process of a liquid in a container.

[0041] Non-limiting, exemplary embodiments of the invention will now be described with reference to the accompanying drawings, in which:

Figure 1 shows a schematic view of a system according to the invention comprising an apparatus with a tube and a nozzle head;

Figure 2 shows a perspective view of the nozzle head used in the apparatus according to Fig. 1;

Figure 3 shows a transparent perspective view of the nozzle head shown in Fig. 2; and

Figure 4 shows a schematic view of an alternative embodiment of a system according to the invention, wherein the gas is supplied via a gas inlet device and thus via a bottom of a removable container.

[0042] Figure 1 depicts a first embodiment of a system with an apparatus 1 and a container 100 for carbonation of a liquid inside the container 100. In this regard, the difference between an apparatus 1 and a system is that the system at least further includes the removable container 100.

[0043] The apparatus 1 comprises a canister or gas bottle 2 comprising pressurized gas and a pressure regulator 3 coupled to said canister 2, wherein the pressure regulator 3 and the canister 2 together form a pressure supply unit 4. Furthermore, the apparatus 1 comprises a suction pump 5, a head portion 6, which is connected to a spout portion of the container 100, for example via corresponding sealing means, wherein said spout portion comprises an opening. A tube 7 with a nozzle head 8 protrudes into the container 100 via said opening. A detailed view of the nozzle head 8 is shown in Figures 2 and 3.

[0044] All components of the system are connected to each other via corresponding fluid conduits 9, with valve 10 and connection means 11 being arranged in the fluid conduits 9. The fluid conduits 9 are only schematically indicated. However, the fluid conduits 9 may be respective flexible and/or rigid pipes or the like. In particular, the valve 10 and connection means 11 may be omitted and are not necessarily required for an implementation of the invention. A control unit is not shown here, however, a respective control unit may comprise a processor, a memory and the like and is configured to control the corresponding components of the apparatus 1. Consequently, the control unit is linked to the respective component parts of the apparatus 1 such as the suction pump 5 and valve 10.

[0045] Further, the container 100 comprises a height, not shown, wherein the nozzle head 8 depicted in Figure 1 is arranged within the third, actually even within the quarter, of the container (height) nearer to the bottom 101 of the container 100. When gas is supplied from the pressure supply unit 4, the gas flows according to arrow 12 shown inside the tube 7, wherein arrow 12 also refers to a direction of extension of the tube 7, i.e., a distal extension towards the bottom 101 of the container 100. Arrow 13 refers to a direction perpendicular to said direction of extension 12. Therefore arrow 12 is pointing towards sidewall 102 of the container 100, wherein arrow 13 is pointing towards the bottom 101 of the container 100.

[0046] Figures 2 and 3 both show an embodiment of the nozzle head 8 with a cylindrical shape comprising a bottom surface 14, lateral surface 15 and top surface 16. The top surface 16 is directed towards the opening of the container 100, wherein the bottom surface 14 is directed towards the bottom 101 of the container 100, and the lateral surface 15 is directed towards the sidewall 102 of the container 100 as can be seen in Figure 1. The nozzle head 8 further comprises nozzle outlets 17 arranged on the lateral surface 16. Gas which flows out of the nozzle outlets 17 is therefore directed according to arrow 13 and thus in a direction perpendicular to the extension of the tube 7. Further, to be connected to the tube 7 the nozzle head 8 comprises a respective threaded portion 18, in which the tube 7 is inserted. Even though not shown, to be connectable to the tube 7, the tube 7 requires a respective threaded portion to be engaged with said threaded portion 18. The threaded portion 18 is connected via fluid channels 19 with the nozzle outlets 17 of the nozzle head 8.

[0047] Figure 4 shows a similar system as depicted in Figure 1. However, the system of Figure 4 does not comprise a tube 7 and a nozzle head 8. Instead, the system depicted in Figure 4 comprises a gas inlet device 20 and the container 100 comprises a respective counterpart so that the gas is supplied into the container 100 via said gas inlet device 20 and the counterpart, for example a valve mechanism, at the bottom 101 of the container 100. The gas inlet device 20 is only indicated and not actually depicted. However, the gas inlet device would be located at the location of reference sign 20. Therefore, reference sign 20 refers to the schematically indicated gas inlet device 20 which is only schematically depicted.

[0048] Further, a relief valve 21 is depicted on the head portion 6 of the apparatus 1. The relief valve 21 is also shown in Figure 1 and is used to ensure that the pressure inside the container 100 does not become too high. For example, the relief valve 21 may be set to open when the pressure rises e.g. above 8 bar inside the container 100. In the specific embodiment depicted in Figure 1, the pressure head has two relief valves 21, wherein the second pressure relief valve 21 is optional. If two pressure relief valves 21 are provided, preferably one opens at a pressure above 8 bar, and the second one opens at a pressure above 11 bar. Furthermore, the apparatuses 1 in Figures 1 and 4 optionally comprise a pressure compensation valve 22, which may be opened, for example, at the end of an enrichment process to compensate for the overpressure in the system. The valves 10, 21 and 22 may all be operated by the control unit, not shown.

[0049] When a user operates the system or the apparatus 1 according to the invention, first, before a respective gas enrichment of a liquid inside the container 100 can take place, liquid has to be filled into the container 100. Therefore, the user may use tap water or may use the apparatus 1 itself, which may then require a tank.

[0050] Thus, once the container 100 is filled with liquid up to a specified liquid level value, for example up to 0.8 liter for a container with a maximum fill volume of 1 liter, the user may place the container 100 inside the apparatus 1.

[0051] The enrichment process may then start. Regardless of whether, for example, a system according to Figure 1 or a system according to Figure 4 is used, the user starts the enrichment process, for example, by pressing a button on an interface of the apparatus 1. For this purpose, the user may select medium sparkling. The apparatus 1 now opens the valve 10 and, may also set the pressure regulator 3 according to the selection of the user. The gas, for example CO_2, starts to flow via the fluid conduits 9 via the head portion 6, the tube 7, the nozzle head 8 and the nozzle outlets 17 into the container 100 or via the gas inlet device 20 located at the bottom 101 of the container 100. The pressurized gas then enters the liquid and rises up towards the head portion 6. By doing so, some of the gas will be bound, whereas there will also be remaining unbound gas rising above the liquid.

[0052] At the moment, when the control unit sends a signal to the pressure supply unit 4, i.e., the valve 10 or the pressure regulator 3 respectively, also the suction pump 5 may be started. Therefore, at the time unbound gas rises above the liquid level, the suction pump 5 may be already running. Via respective outlet ports at the head portion 6, the suction pump 5 may then suck out, i.e., extract, the unbound gas out of the container 100 via the opening of the container 100.

[0053] The extracted gas is then reintroduced to the liquid via the nozzle head 8 or the gas inlet device 20 such as the gas from the pressure supply unit 4 before. This suction process continuous until the enrichment process is completed to the intended degree.

[0054] During the enrichment process, i.e., the carbonation of the liquid, the pressure supply unit 4 may supply gas to the liquid in a pulsed manner, wherein, for example, the valve 10 opens only for a predetermined period, for example, 1 second every 5 seconds over the duration of 60 seconds. This means that the gas flow via the pressure supply unit 4 may be operated in a pulsed manner, wherein the unbound gas is always pumped back into the liquid via the suction pump 5. Alternatively, the gas is supplied to the liquid via the nozzle head 8 or the gas inlet device 20 continuously.

[0055] As soon as the enrichment process is complete, i.e., for example, when the 60 seconds have elapsed or a sensor detects that there is sufficient gas in the liquid or the like, the enrichment process is stopped by the control unit. Therefore, the pressure supply unit 4 as well as the suction pump 5 are stopped. If necessary, the control unit may then open the optional pressure compensation valve 22 to compensate for the excess pressure in the container 100. The user may then remove the container 100 from the apparatus 1, wherein the liquid in the container 100 is now ready to drink and conditioned according to the selection made by the user.

[0056] Even though described here, some components such as a suction pump 4 is not necessarily required and may only be used to further optimize the enrichment process.

[0057] In the following, results of experiments are described, wherein an embodiment with a system according to Figure 1 and a nozzle head 8 according to Figure 2 was used (see below, table 1). Further, comparative experiments were conducted for a product which is already available on the market, the "BRITA sodaONE" (see below, table 2).

[0058] For testing with a system according to Figures 1 and 2, a container was filled with 0.8 liter of water. During testing, the distance between the bottom surface 14 of the nozzle head 8 and the bottom 101 of the container 100 was about4 cm, wherein the nozzle head was located within around the 19/23 of the container height, since the tube 7 with nozzle head 8 protrudes with a length of about 19 cm into the container 100 having a container height of about 23 cm. The nozzle head 8 used for testing had 12 nozzle outlets 17 directed towards the sidewall 102 of the container. Each nozzle outlet 17 had a diameter of 0.3 mm. As can be seen from table 1, each pulse experiment was repeated five times with the same parameters to check reproducibility. Therefore, for each test experiment of a test series the cycle time, burst time and number of bursts as well as the maximum pressure were identical. Only the water temperature changed slightly between each experiment.

Table 1: System according to Figures 1 and 2 of the present invention

System according to Figures 1 and 2 of the present invention										
test series	test no.	cylcetime (s)	bursttime (s)	breaktime (s)	temp. (C°)	max. pressure (bar)	discharged CO2-gas (g)	CO2-enrichment in the liquid (g/l)	efficiency (%)	mean efficiencyvalue (%)
1	1	30	1	5	18.5	3	5.71	4.07	71.3	79.4
	2	30	1	5	18.3	3	5.42	4.37	80.6	
	3	30	1	5	18.1	3	5.70	4.25	74.6	
	4	30	1	5	17.9	3	5.33	4.37	82.0	
	5	30	1	5	17.8	3	4.98	4.40	88.4	
2	1	60	1	10	17.6	3	5.59	4.79	85.7	81.2
	2	60	1	10	17.7	3	5.94	4.58	77.1	
	3	60	1	10	17.6	3	5.75	4.78	83.1	
	4	60	1	10	17.5	3	5.69	4.80	84.4	
	5	60	1	10	17.6	3	6.37	4.83	75.8	
3	1	30	1	10	17.7	3	3.96	3.89	98.2	92.3
	2	30	1	10	17.7	3	4.71	3.89	82.6	
	3	30	1	10	17.7	3	4.21	4.02	95.5	
	4	30	1	10	17.9	3	4.23	3.71	87.7	
	5	30	1	10	17.7	3	4.08	3.98	97.5	
4	1	60	1	20	17.5	3	5.27	3.99	75.7	77.1
	2	60	1	20	17.7	3	5.78	4.00	69.2	
	3	60	1	20	17.5	3	5.17	4.07	78.7	
	4	60	1	20	17.5	3	5.10	3.94	77.3	
	5	60	1	20	17.6	3	4.80	4.06	84.6	
5	1	30	1	10	18.1	4	5.42	3.89	71.8	77.1
	2	30	1	10	18.2	4	5.82	4.27	73.4	

(continued)

System according to Figures 1 and 2 of the present invention										
test series	test no.	cylcetime (s)	bursttime (s)	breaktime (s)	temp. (C°)	max. pressure (bar)	discharged CO2-gas (g)	CO2-enrichment in the liquid (g/l)	efficiency (%)	mean efficiencyvalue (%)
	3	30	1	10	18.3	4	4.75	4.14	87.2	
	4	30	1	10	18.2	4	5.81	4.38	75.4	
	5	30	1	10	18.2	4	5.36	4.18	78.0	
6	1	60	1	20	17.8	4	6.73	4.40	65.4	74.1
	2	60	1	20	17.6	4	5.85	4.30	73.5	
	3	60	1	20	17.6	4	5.54	4.44	80.1	
	4	60	1	20	17.5	4	5.74	4.42	77.0	
	5	60	1	20	17.5	4	5.96	4.44	74.5	
7	1	30	1	5	18.1	3.5	6.15	4.42	71.9	69.5
	2	30	1	5	18.0	3.5	6.31	4.61	73.1	
	3	30	1	5	18.0	3.5	7.06	4.64	65.7	
	4	30	1	5	18.0	3.5	6.56	4.44	67.7	
	5	30	1	5	18.0	3.5	6.51	4.51	69.3	
8	1	45	1	7,5	18.1	3.5	6.94	4.71	67.9	70.4
	2	45	1	7,5	17.8	3.5	6.86	4.70	68.5	
	3	45	1	7,5	17.7	3.5	6.96	4.88	70.1	
	4	45	1	7,5	17.7	3.5	6.77	4.93	72.8	
	5	45	1	7,5	17.5	3.5	6.77	4.93	72.8	
9	1	60	1	10	17.5	3.5	7.43	5.09	68.5	68.4
	2	60	1	10	17.5	3.5	7.37	4.80	65.1	
	3	60	1	10	17.4	3.5	7.75	4.99	64.4	
	4	60	1	10	17.4	3.5	7.08	5.13	72.5	
	5	60	1	10	17.4	3.5	7.28	5.20	71.4	

[0059] The "cycle time" corresponds to the time from the first burst until the pressure inside the container is released, for example by means of a pressure compensation valve. The "burst time" is the duration of a CO_2-gas burst. The selected pressure for each burst is indicated in table 1. The "discharged CO_2-gas (g)" defines the amount of CO_2-gas in gram which was discharged from a canister during the enrichment process, wherein the "CO_2-enrichment in the liquid (g/l)" defines the amount of CO_2-gas in gram being accumulated per liter inside the liquid. Thus, the "efficiency (%)" for each test was calculated by relating the "consumption CO_2 (g)" to the "CO_2-enrichment in the liquid (g/l)" in order to determine how much percentage of the discharged CO_2-gas was bound inside the liquid.

[0060] For example, for the first experiment of the first test series, the water temperature was 18.5 °C and the maximum pressure inside the container was 3 bar. Further, the cycle time was set to 30 seconds, with each burst lasting 1 second. The total number of bursts was thus 5. The break time between a burst and a subsequent burst as well as after the last burst was 5 seconds. In this experiment, 5.71 g of CO_2-gas were discharged, and 4.07 g of CO_2-gas were accumulated per liter. The efficiency for this experiment was therefore 71.3 %.

[0061] In order to put the results into perspective and make the increase in efficiency of the present invention visible, the above described experiments according to the invention summarized in Table 1 were compared with a conventional carbonation apparatus working according to the so-called "batch"-method wherein the full CO_2 pressure from the CO_2 gas bottle is applied. The comparative experiments were carried out with the "BRITA sodaONE", which is already available on the market. This sodaONE-apparatus comprises a tube which projects into a liquid in approximately the upper third of a container used with said apparatus. The tube has only one outlet. During the test trials, an attempt was made to obtain a comparable enrichment of CO_2-gas in the liquid as with the results obtained with an embodiment according to the invention, as shown in table 1.

Table 2: BRITA sodaONE

BRITA sodaONE										
test series	**test no.**	**cylcetime (s)**	**bursttime (s)**	**number of bursts**	**temp. (C°)**	**max. pressure (bar)**	**discharged CO2-gas (g)**	**CO2-enrichment in the liquid (g/l)**	**efficiency (%)**	**mean efficiencyvalue (%)**
1	1	3	3	3	17.9	60	8	4.6	57.5	64.0
	2	3	3	3	17.9	60	6.3	4.7	74.6	
	3	3	3	3	17.9	60	8.2	4.9	59.8	
2	1	6	3	3+2	17.7	60	12	5.2	43.3	44.2
	2	6	3	3+2	17.8	60	12.1	5.4	44.6	
	3	6	3	3+2	17.7	60	12.1	5.4	44.6	
3	1	9	3	3+2+2	17.8	60	15.6	5.6	35.9	35.2
	2	9	3	3+2+2	17.7	60	15.8	5.4	34.2	
	3	9	3	3+2+2	17.8	60	15.2	5.4	35.5	
4	1	12	3	3+2+2+2	17.8	60	18.7	5.6	29.9	29.3
	2	12	3	3+2+2+2	17.7	60	18.3	5.4	29.5	
	3	12	3	3+2+2+2	17.7	60	18.9	5.4	28.6	

[0062] The experiments in table 2 with the sodaONE-apparatus, were performed by pressing the button for CO2-gas release, i.e. for enriching the liquid inside the respective bottle used with the apparatus, with the number of bursts indicated in table 2, with a respective break time of 1 second after each burst in each test series. In each test series, the burst time for the first burst was 3 seconds, thereafter, the relief valve opened. However, for the subsequent gas bursts applied in test series 2, 3 and 4, the burst time for each burst subsequent to the first gas burst was 2 seconds, because after the first gas burst, there was already pressure in the bottle, and therefore, the relief valve opens earlier compared to the first gas burst. During the experiments, the bottle was filled with 0.8 liters of water. To obtain a desired enrichment of 4.5 to 5.5 g CO_2-gas per liter in the liquid, for example,the cycle times and number of bursts were varied as show in table 2. Table 2, thus, shows four different test series, wherein each test series comprises three experiments. As for table 1, only the water temperature changed a little between each experiment of a test series.

[0063] As derivable from table 2, a first experiment (cf. test series 1) at a temperature of 17.9 °C was conducted with a cycle time of 3 seconds, a burst time of 3 seconds and a total number of 1 bursts, that is CO_2 was not applied in a pulsed manner here. During this first experiment, 8 g CO2-gas was discharged from a canister and 4.6 g per liter were bound inside the liquid. Therefore, for this experiment, the efficiency was determined at 57.5 %, which is significantly less than that of the present invention shown in table 1. In the further experiments test series 2 to 4 indicated in table 2, CO_2 was applied in a pulsed manner, however, efficiency was even poorer compared to test series 1 of table 2 in which CO_2 was not applied in a pulsed manner. Hence, it was surprisingly found that by advantageously setting the parameters CO_2 pressure, cycle time, burst time and time period between the gas bursts (break time), efficiency of CO_2 application can be significantly improved.

Reference signs

[0064]

1	apparatus
2	canister/gas bottle
3	pressure regulator
4	pressure supply unit
5	suction pump
6	head portion
7	tube
8	nozzle head
9	fluid conduits
10	valve
11	connection means
12	arrow (direction of extension of the tube)
13	arrow (direction perpendicular to the direction of extension of the tube)
14	bottom surface
15	lateral surface
16	top surface
17	nozzle outlets
18	threaded portion
19	fluid channels
20	gas inlet device
21	relief valve
22	pressure compensation valve (optional)
100	(removable) container
101	bottom
102	sidewall

Claims

1. A system comprising a removable container (100) and an apparatus (1) for carbonation of a liquid inside the container (100),

wherein the container (100) comprises a container height between a bottom (101) and an opening, and wherein the apparatus (1) is configured to hold the container (100) and comprises:

a pressure supply unit (4) for providing pressurized gas, and
a tube (7) connected to the pressure supply unit (4), wherein the tube (7) has an inner diameter, and wherein the tube (7) is at least partially received via the opening within the container (100) when the container (100) is held in the apparatus (1),
characterized in
a nozzle head (8) connected to the tube (7) and comprising at least one nozzle outlet (17) for supplying the gas to the liquid inside the container (100), wherein a diameter of the at least one nozzle outlet (17) is smaller than the inner diameter of the tube (7), and wherein when the container (100) is held in the apparatus (1),
the nozzle head (8) is located within the third of the container height nearer to the bottom (101) of the container (100).

2. The system according to claim 1, wherein the apparatus (1) comprises a suction pump (5) releasably connectable to the opening of the container (100) and to the tube (8) when the container (100) is held in the apparatus (1), wherein the suction pump (4) is configured to extract gas from the container (100) and to reintroduce said gas into the liquid inside the container (100) via the nozzle head (8).

3. The system according to claim 1 or 2, wherein the apparatus (1) comprises a control unit configured to operate the pressure supply unit (4) in a pulsed manner with at least two gas bursts.

4. An apparatus for carbonation of a liquid inside a removable container (100) with a bottom (101) and an opening, for example the apparatus of the system according to any one of the preceding claims, the apparatus (1) comprising:

a pressure supply unit (4) for supplying pressurized gas to the liquid inside the container (100) when the container (100) is held in the apparatus (1),
characterized in
a suction pump (5) releasably connected to the container (100) when the container (100) is held in the apparatus (1),
and a control unit configured to operate the pressure supply unit (4) in a pulsed manner with at least two gas bursts, and to operate the suction pump (5) to extract gas from the container (100) and reintroduce said gas into the liquid inside the container (100).

5. The apparatus (1) according to claim 4, wherein the pressure supply unit (4) is configured to supply gas into the liquid within the third of the container (100) height nearer to the bottom (101) of the container (100); and/or
the pressure supply unit (4) is configured to either supply gas into the liquid via an opening of the container (100) via a tube (7) and a nozzle head (8) with at least one nozzle outlet (17) or via a gas inlet device (20) provided at the bottom (101) of the container (100), preferably the pressure supply unit (4) is configured to supply gas into the liquid via the opening of the container (100) via a tube (7) and a nozzle head (8) with at least one nozzle outlet (17).

6. The apparatus (1) according to claim 5, wherein the nozzle (8) head is releasable attachable to the tube (7) and/or the tube (7) is releasable attachable to the apparatus (1), for example by a threaded interface.

7. The apparatus (1) according to any one of claims 5 or 6, wherein the nozzle head (8) comprises at least two nozzle outlets (17), preferably at least six nozzle outlets (17), more preferably at least twelve nozzle outlets (17), most preferably twelve to twenty nozzle outlets (17).

8. The apparatus (1) according to any one of claims 5 to 7, wherein the nozzle outlets (17) are directed in a direction of extension of the tube and/or radially, perpendicular to the direction of extension of the tube.

9. The apparatus (1) according to any one of claims 5 to 8, wherein the diameter of each nozzle outlet (17) is between 0.2 mm and 0.8mm, preferably between 0.24 mm and 0.5 mm, more preferably between 0.28 mm and 0.4 mm.

10. The apparatus (1) according to any one of claims 5 to 9, wherein the nozzle head (8) comprises a cylindrical or disk shape with a lateral surface (15), a bottom surface (14) and a top surface (16), and wherein the nozzle outlets (17) are arranged on the lateral surface (15) and/or the bottom surface (14) of the nozzle head (8).

11. The apparatus (1) according to any one of claims 4 to 10, further comprising a pressure regulator (3) for setting the pressure of supplied gas, wherein the pressure regulator (3) provides the supplied gas at a maximum pressure of 8 bar, preferably a pressure between 2 bar and 6 bar, more preferably a pressure between 2.5 bar and 4.5 bar, most preferably a pressure between 2.8 bar and 3.2 bar.

12. The apparatus (1) according to any one of claims 4 to 11, wherein the control unit is configured to operate the pressure supply (4) unit such that a period of 4 to 20 seconds between two consecutive gas bursts occurs during which no gas burst is provided by the pressure supply unit (4), preferably said period is between 5 to 15 seconds, more preferably said period is between 5 to 10 seconds.

13. The apparatus (1) according to any one of claims 4 to 12, wherein for the enrichment of gas in the removable container (100), the control unit is configured to operate the pressure supply unit (4) in a pulsed manner for 30 to 120 seconds, preferably for 30 to 90 seconds, more preferably for 30 to 60 seconds; and/or wherein each gas burst lasts between 0.8 and 5 seconds, preferably between 0.8 and 3 seconds, more preferably between 0.8 and 2 seconds, most preferably between 0.9 and 1.2 seconds.

14. The apparatus (1) according to any one of claims 4 to 13, wherein the control unit operates the suction pump (5) to continuously suck gas from the container (100) directly after the first gas burst.

15. The apparatus (1) according to any one of claims 4 to 14, wherein the control unit comprises a printed circuit board assembly (PCBA) and is connected to a power supply.

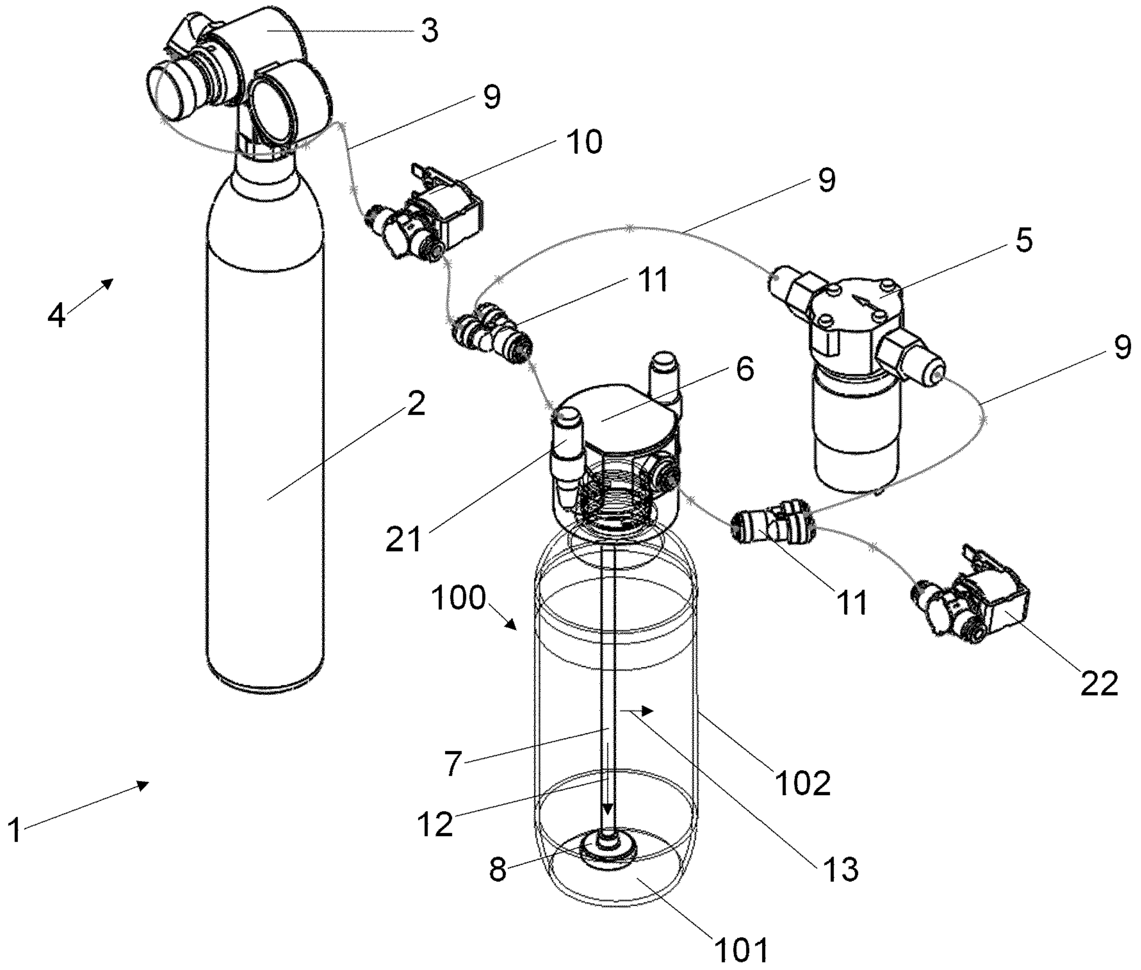

Fig. 1

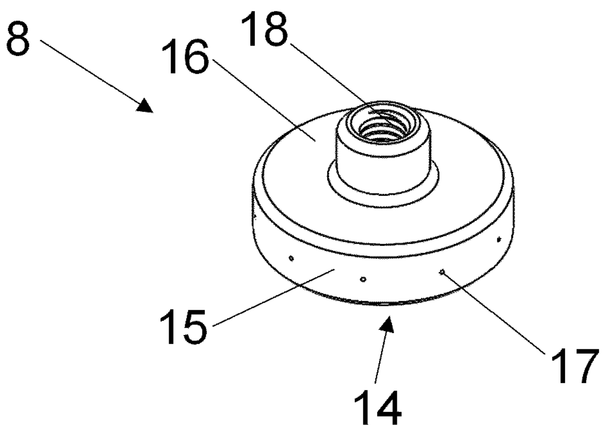

Fig. 2

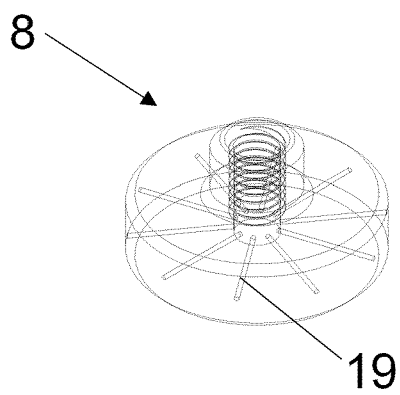

Fig. 3

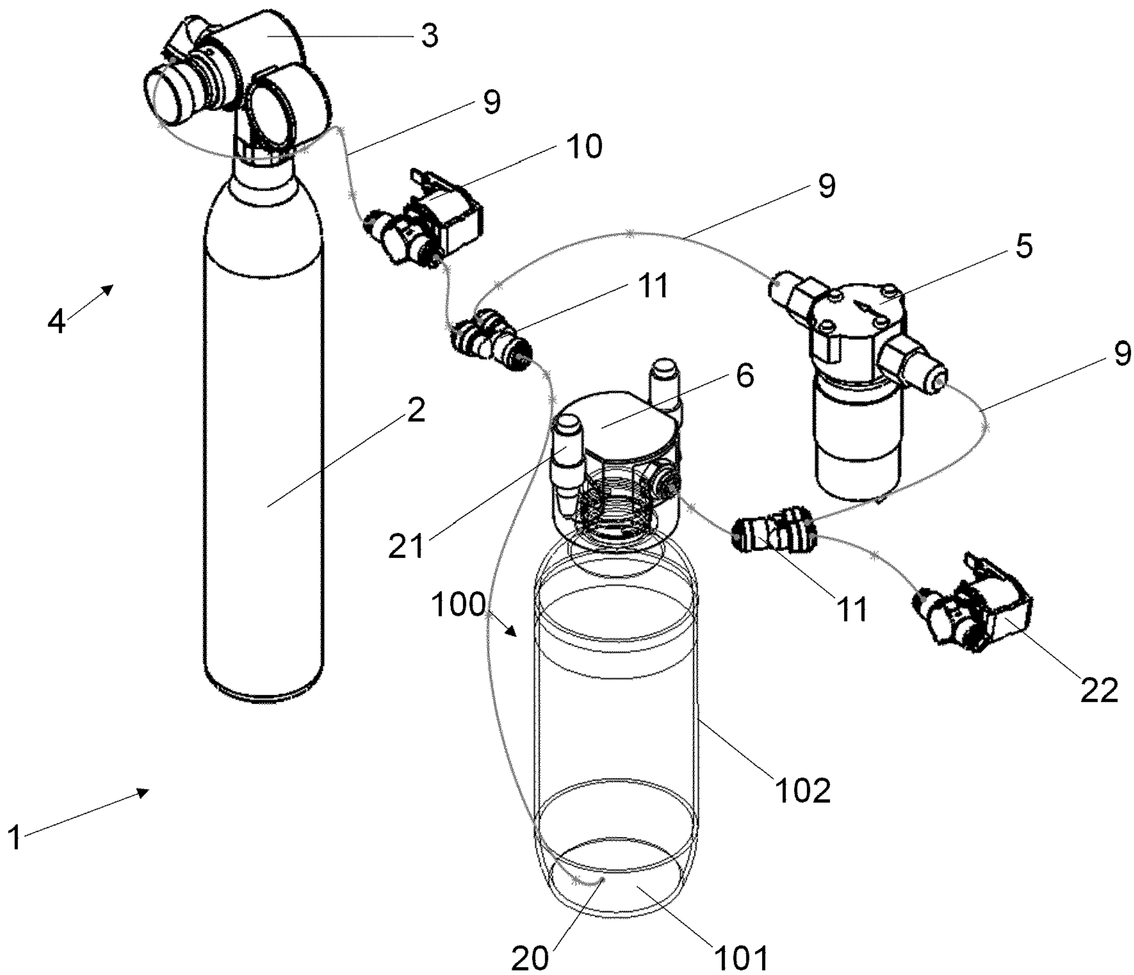

Fig. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 22 15 5353

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~~The present search report has been drawn up for all claims~~

1

Place of search	Date of completion of the search	Examiner
The Hague	26 August 2022	Real Cabrera, Rafael

CATEGORY OF CITED DOCUMENTS

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EUROPEAN SEARCH REPORT

Application Number
EP 22 15 5353

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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~~The present search report has been drawn up for all claims~~

1

Place of search	Date of completion of the search	Examiner
The Hague	26 August 2022	Real Cabrera, Rafael

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Application Number
EP 22 15 5353

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☒ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

1-3

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).

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LACK OF UNITY OF INVENTION SHEET B

Application Number
EP 22 15 5353

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-3

System for carbonation comprising a removable container and an apparatus for carbonation, wherein the apparatus comprises a tube and nozzle head with at least one nozzle outlet connected to the tube, a diameter of the at least one nozzle outlet being smaller than the inner diameter of the tube, the nozzle head being located within the third of the container height nearer to the bottom of the container.

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2. claims: 4-15

Apparatus for carbonation comprising a pressure supply unit, a suction pump and a control unit configured to operate the pressure supply unit in a pulsed manner with at least two gas bursts, and to operate the suction pump to extract gas from a container and reintroduce said gas into a liquid inside the container.

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 22 15 5353

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

26-08-2022

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