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(54) SYSTEMS AND METHODS FOR TRANSFERRING AND DELIVERING A LIQUID CHEMICAL FROM A SOURCE TO AN END USE STATION

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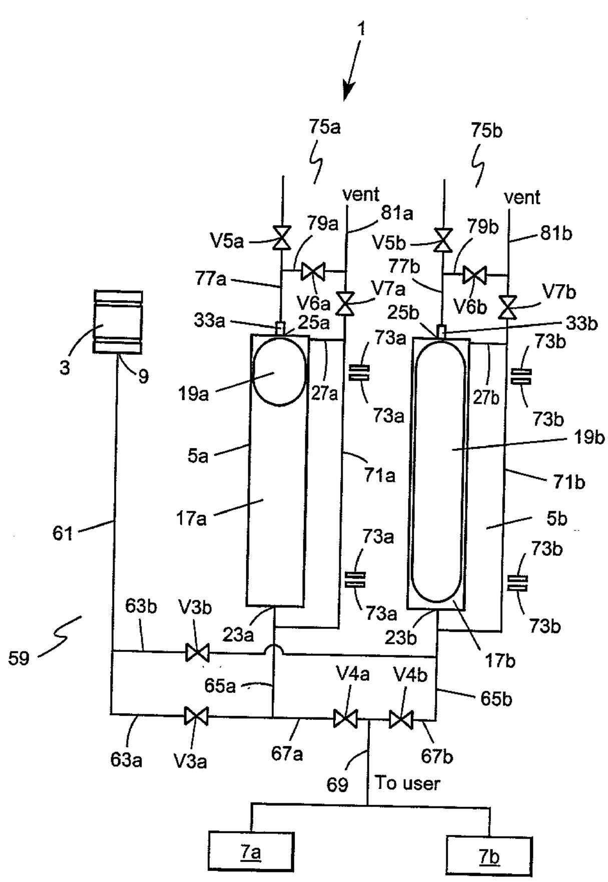
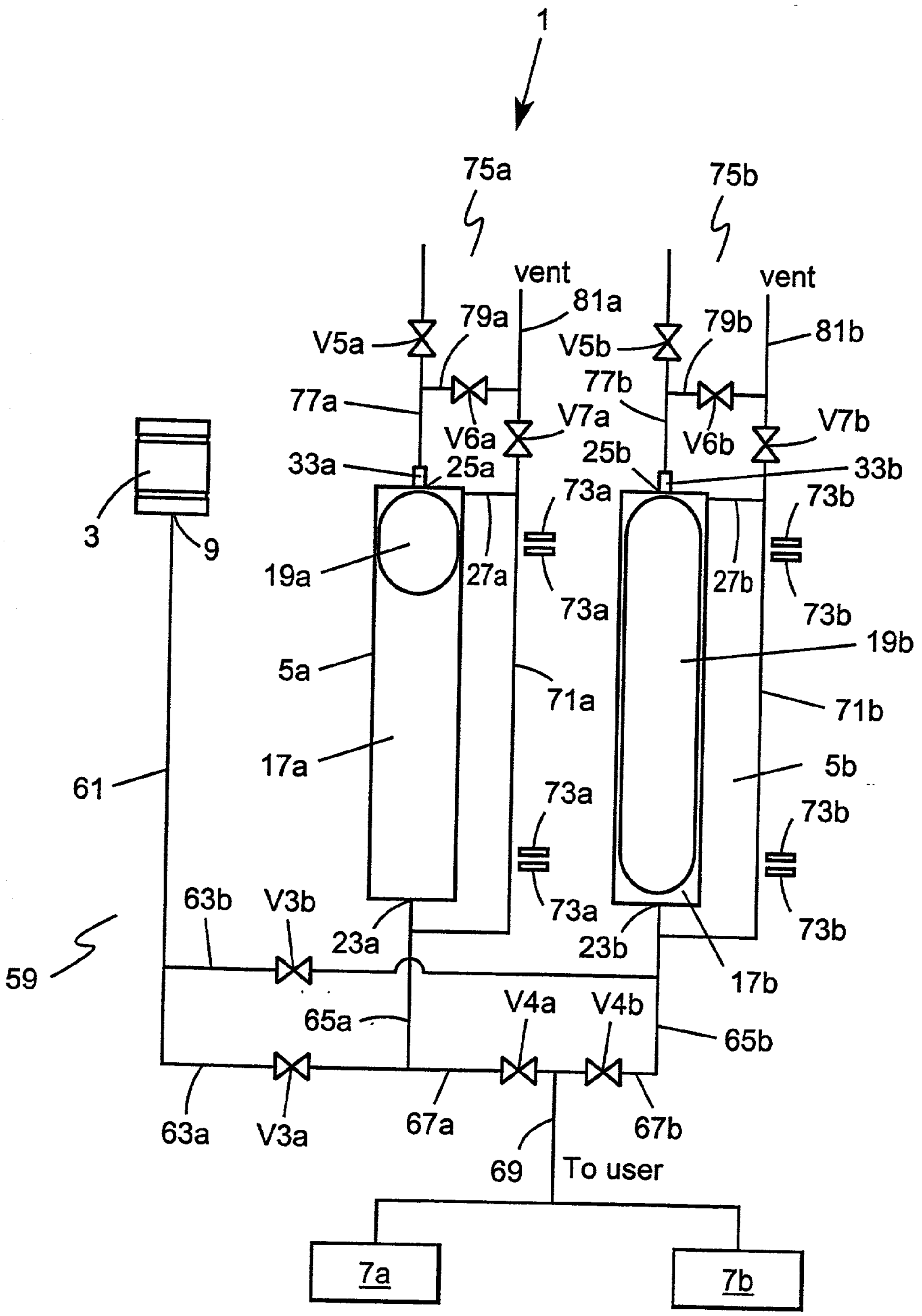
(57) **ABSTRACT**

Provided is a system for transferring and delivering a liquid chemical from a source to an end use station. The system includes: (a) a pressure vessel connected to a liquid chemical source by a delivery conduit, the pressure vessel having an internal surface; (b) a non-mechanical means of transferring the liquid chemical from the source through the delivery conduit to the pressure vessel; (c) a flexible liquid metering device disposed within the pressure vessel, the metering device having an interior and an interior surface and an exterior and an exterior surface; (d) a space adapted to receive the liquid chemical, the space being defined by at least a portion of the metering device external surface and at least a portion of the pressure vessel interior surface, or by at least a portion of the metering device internal surface; and (e) a pressurized gas conduit connected to a pressurized gas source for delivering the pressurized gas into the pressure vessel so as to contact the other of the interior or exterior surface of the metering device that defines the space, whereby the liquid chemical is forced out of the pressure vessel by the metering device to an end use station. Also provided is a method of transferring and delivering a liquid chemical from a source to an end use station. The invention has particular applicability to the semiconductor manufacturing industry for the distribution of ultrapure liquid chemicals to end use stations.

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To user
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FIG. 1

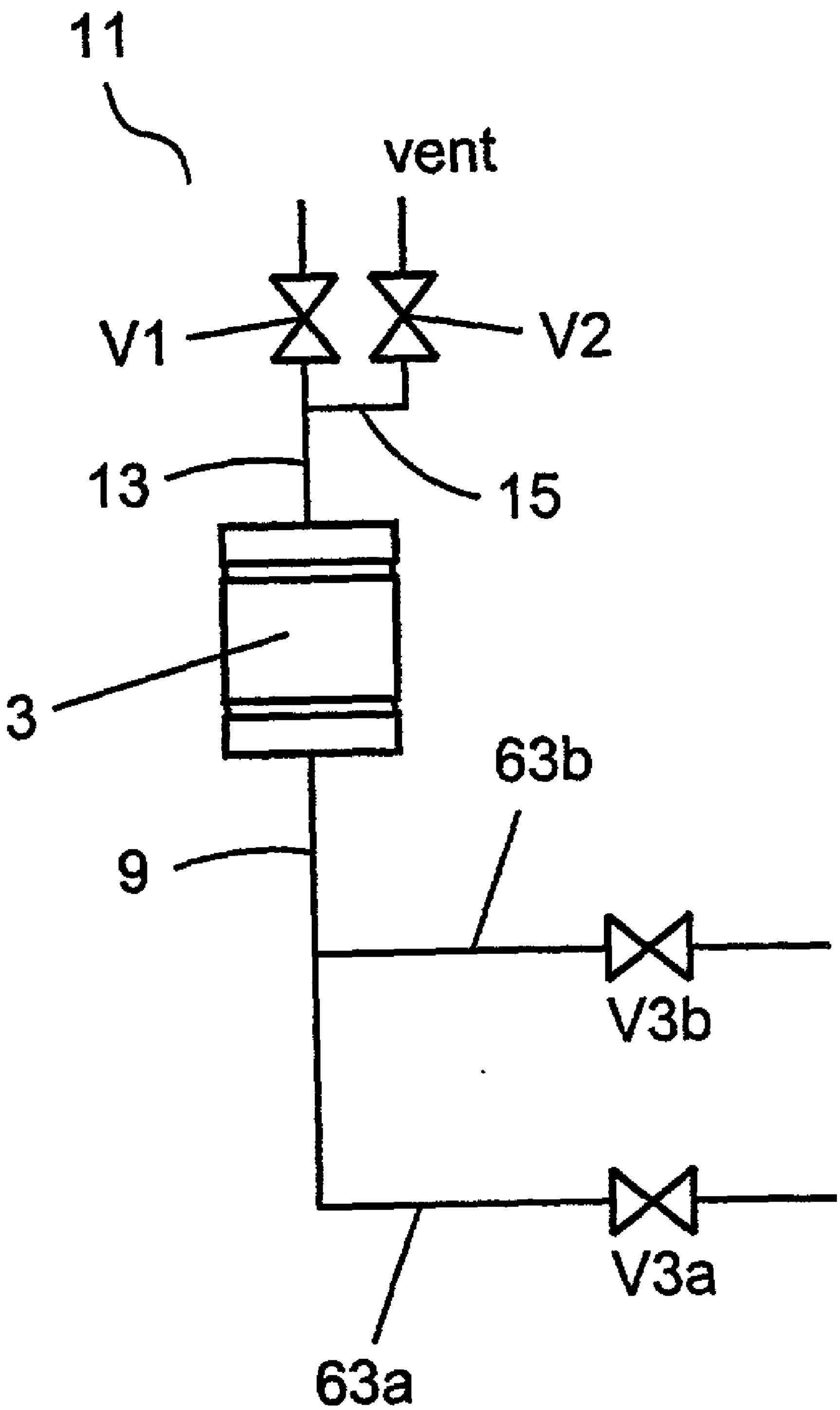

FIG. 2

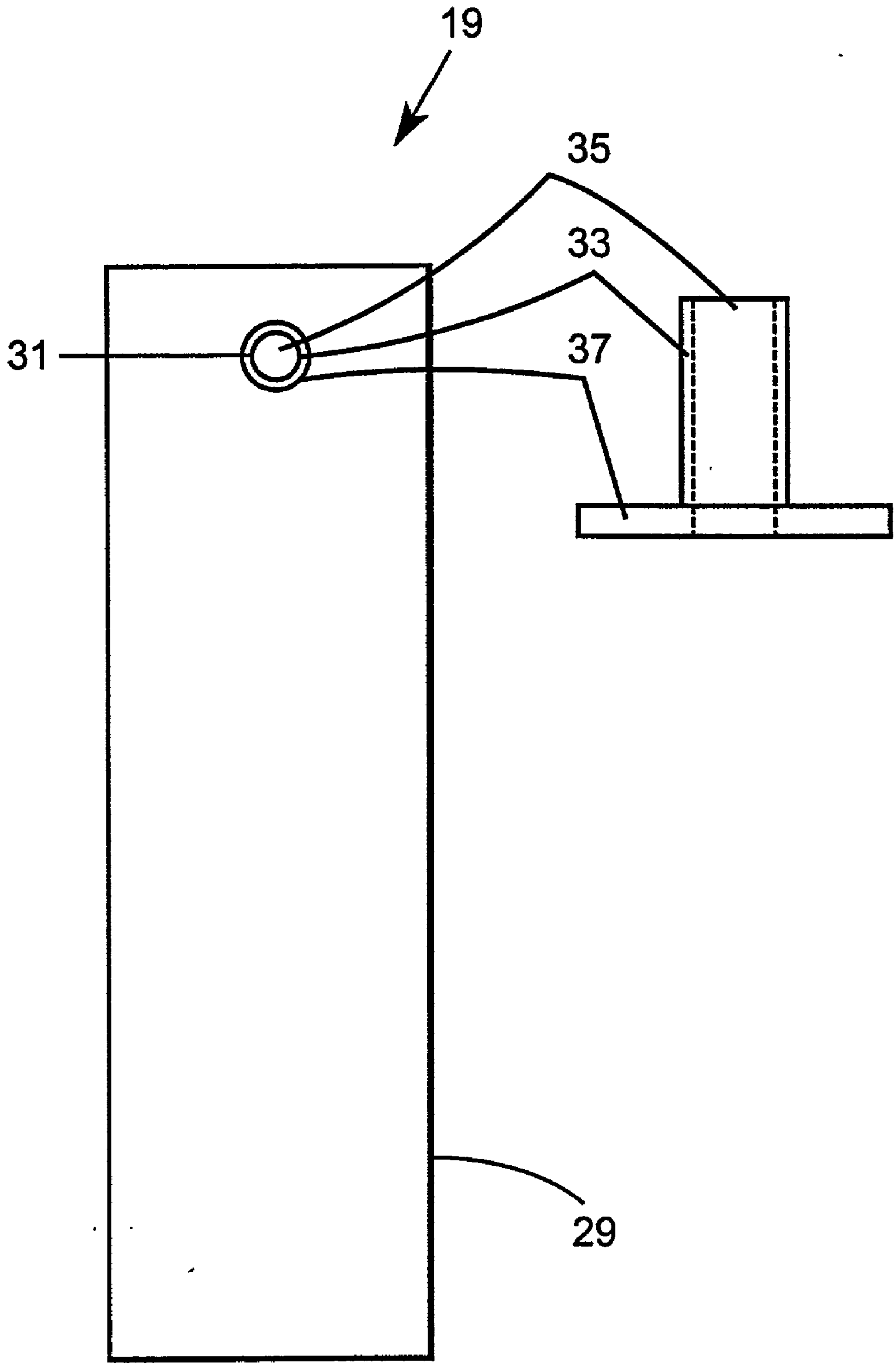

FIG. 3

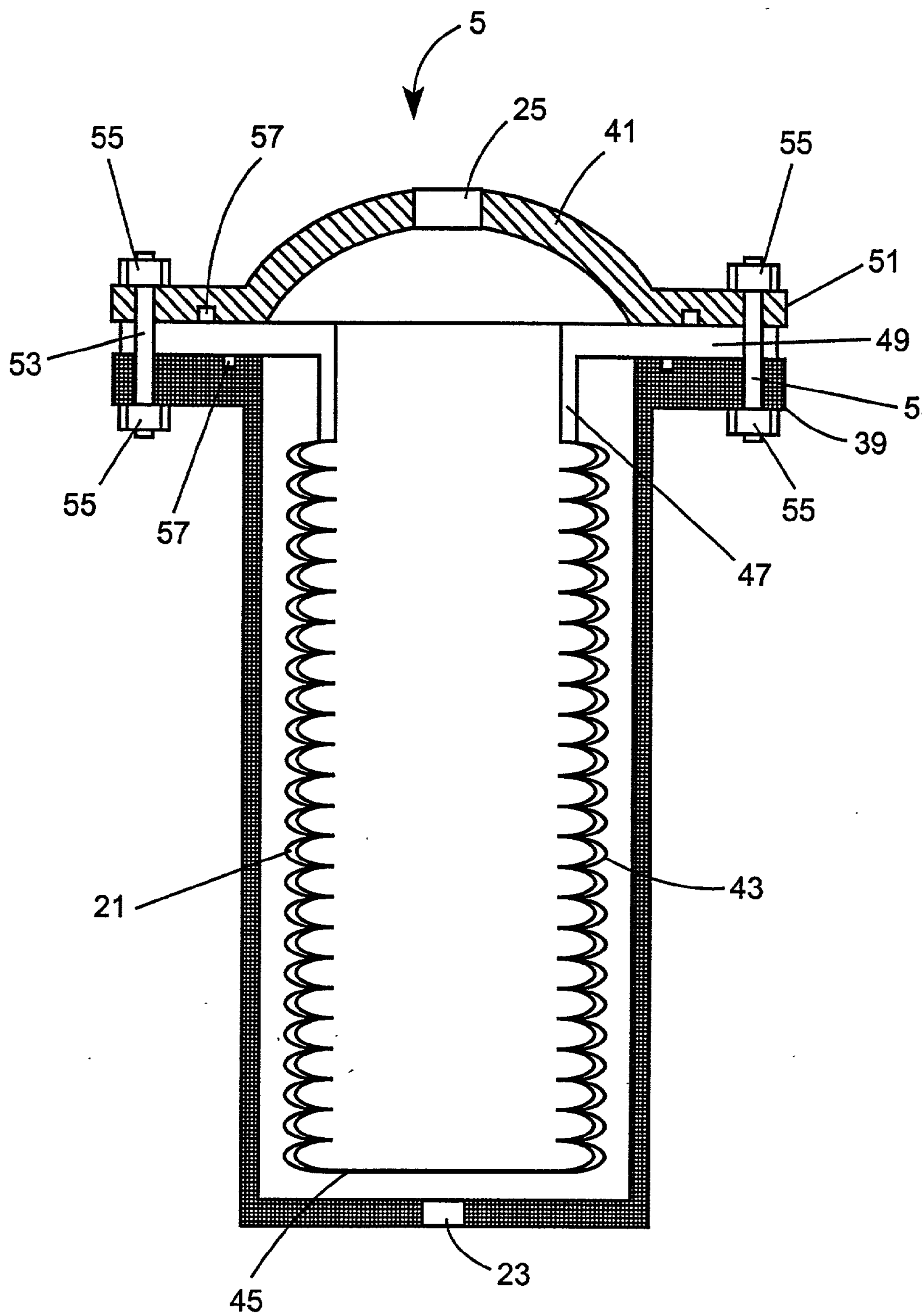

FIG. 4

SYSTEMS AND METHODS FOR TRANSFERRING AND DELIVERING A LIQUID CHEMICAL FROM A SOURCE TO AN END USE STATION

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] This invention relates to systems for transferring and delivering liquid chemicals from a source to an end use station. The invention also relates to methods for transferring and delivering liquid chemicals from a source to an end use station. The invention has particular applicability to the semiconductor manufacturing industry for the distribution of ultrapure liquid chemicals to one or more end use stations.

[0003] 2. Description of the Related Art

[0004] In many manufacturing processes, various chemicals are required to be distributed from a bulk source to the point-of-use, i.e., end use station, without contamination or deterioration of the chemical quality. For example, in semiconductor wafer and computer chip manufacturing processes, ultrapure chemicals are needed for processes such as cleaning, etching, and surface treatment. These chemicals may include, for example, caustic, acids, and organic liquids, such as ammonium hydroxide, sodium hydroxide, hydrofluoric acid, nitric acid, sulfuric acid, phosphoric acid, acetic acid, hydrogen peroxide, isopropyl alcohol, tetramethylammonium hydroxide, photoresists, dopants, chemical slurry, and mixtures of the above or other chemicals. The chemicals must be at the user's point regardless of whether there is continuous or intermittent usage. The chemicals must also be maintained at a high purity level and without being contaminated during the delivery and distribution from bulk sources.

[0005] A few methods have been provided for distributing liquid chemicals. One method is the so called "vacuum-pressure" distribution disclosed by Johns (WO92/05406), Magnasco and Viale (U.S. Pat. No. 4,524,801), Geatz (U.S. Pat. No. 5,148,945), Bernosky et al (WO94/21551, U.S. Pat. No. 5,370,269), and Ferri and Geatz (U.S. Pat. No. 5,330,072 and U.S. Pat. No. 5,417,346). The basic idea is that the chemical to be delivered is withdrawn from a bulk chemical source by virtue of the vacuum inside a pressure vessel created with a vacuum pump, and is then distributed to the user by pressurizing the chemical with an inert gas. The chemical can be distributed continuously with more than two systems in parallel and to a user located at a far distance by operating at a high pressure.

[0006] However, this "vacuum-pressure" method has several drawbacks. First, the chemical can be contaminated by the leakage of ambient air into the system because of the negative pressure inside the system. Another drawback is that the vacuum pump used to create the vacuum has high down-time because of the corrosion of the pump components by chemical vapor and droplets passing through the pump. Yet another drawback is that the exhaust of the inert gas with the chemical vapor and droplets from the vacuuming procedure produces an environmental concern. This exhaust may be saturated by the chemical, especially in the distribution of high vapor pressure chemicals. Since the inert gas directly contacts the chemical at a high pressure, some of the gas will dissolve in the liquid phase and form bubbles in the chemical. The bubbles may result in a serious quality problem in the wafer and electronic chips being manufactured. For example, they may attach to the wafer surface and create a non-wetted spot on the surface.

[0007] Another method to distribute the chemical to the end users is the so-called collapsible container method disclosed by Ramsay (U.S. Pat. No. 5,570,815). With this method, the chemicals to be distributed must be filled within a container with flexible walls. This container is then positioned inside a pressure vessel and squeezed with a high pressure gas. The chemical is thereby pushed out of the container and delivered to the user. The chemical does not directly contact with the high pressure gas as with the vacuum-pressure method. However, the chemical quantity in the container is difficult to be monitored, and therefore, it is difficult to continuously deliver the chemical. Another drawback of this method is that the distribution system with this method cannot be controlled automatically. Further, the collapsible container can be easily broken especially at the fixing points under high pressure because of the disjoining force of the high pressure gas.

[0008] Another widely practiced method is the pumping delivery method. A positive displacement pump, such as a double diaphragm pump driven by air or gas, is used to deliver the chemical from a bulk source or an intermediate container to the end users. Over the years, the lift force of this type of pump has been improved. For example, a Yamada diaphragm pump can operate at a pressure up to 50 psi. This lift force, however, is still not high enough for many applications, especially for the practice of viscous chemicals and long distance delivery. Another drawback is the contamination of the impurities shed from the components of the distribution system due to the flow pulsation produced by the pump.

[0009] Yet another method is the so-called pump-pressure distribution. A pump is employed to deliver the chemical from a bulk source to a pressure vessel. The chemical in the vessel is then pressurized with high pressure gas to be delivered through a distribution system to the end users. Some of the above mentioned drawbacks with the vacuum/pressure and the pump delivery methods still exist. First, the gas directly contacts with the chemical will dissolve in the chemical and form bubbles that can result in serious problems on the wafer or microchip surface. Second, the impurity shedding from the filters and other components by the pulsation upon pump startup will contaminate the ultrapure chemicals.

[0010] Recently, the present inventors have designed a liquid chemical delivery system which employs a pump to transfer a liquid chemical from a bulk source to a delivery vessel. Such a system is disclosed, for example, by Xu et al (U.S. Pat. No. 6,168,048), the entire contents of which are incorporated herein by reference. The delivery vessel includes a balloon inside the delivery vessel which accepts gas. The gas in the balloon forces the liquid chemical out of the delivery vessel. As an improvement in the art, the pump circulates the liquid chemical in the source container through a filter to maximize the removal of particulate contaminants before driving the chemical into the pressure vessel. However, periodic pump maintenance can terminate chemical delivery. In addition, the pump, conduits, filters and other components associated with the pump increases the cost of the system. It would be desirable to eliminate impurities and other problems associated with the use of pumps.

[0011] To meet the requirements of the semiconductor manufacturing industry and to overcome the disadvantages of the related art, it is an object of the present invention to provide novel systems for transferring and delivering a liquid chemical from a source to an end use station.

[0012] It is a further object of the invention to provide novel methods for transferring and delivering a liquid chemical from a source to an end use station.

[0013] Other objects and aspects of the present invention will become apparent to one of ordinary skill in the art on a review of the specification, drawings and claims appended hereto.

SUMMARY OF THE INVENTION

[0014] Through the present invention, problems associated with chemical delivery in the related art have been overcome. For example, the invention makes use of a non-mechanical means of transferring the liquid chemical from the chemical source through the system. As a result, problems associated with pumps such as contamination of the chemical and downtime due to maintenance can be avoided. Also, the delivery system cost is reduced by eliminating the pump and other related components. Additionally, use of a flexible liquid metering device installed inside a pressure vessel isolates a high pressure gas from the chemicals, gas dissolution in the chemical and the resulted gas bubble problems are effectively eliminated. Further, contaminants in the high pressure gas which fills the metering device will not be transferred into the chemical and the extremely toxic chemical will not be transferred into the gas to be exhausted as a serious environmental issue. Unlike the vacuum/pressure system, the contamination by the ambient air leaking into the system is avoided because the disclosed delivery system is always with the pressure higher or equal to the ambient pressure.

[0015] According to a first aspect of the invention, provided is a system for transferring and delivering a liquid chemical from a source to an end use station. The system includes: (a) a pressure vessel connected to a liquid chemical source by a delivery conduit, the pressure vessel having an internal surface; (b) a non-mechanical means of transferring the liquid chemical from the source through the delivery conduit to the pressure vessel; (c) a flexible liquid metering device disposed within the pressure vessel, the metering device having an interior and an interior surface and an exterior and an exterior surface; (d) a space adapted to receive the liquid chemical, the space being defined by at least a portion of the metering device external surface and at least a portion of the pressure vessel interior surface, or by at least a portion of the metering device internal surface; and (e) a pressurized gas conduit connected to a pressurized gas source for delivering the pressurized gas into the pressure vessel so as to contact the other of the interior or exterior surface of the metering device that defines the space, whereby the liquid chemical is forced out of the pressure vessel by the metering device to an end use station.

[0016] According to a further aspect of the invention, a method for transferring and delivering a liquid chemical from a source to an end use station is provided. The method includes:(a) transferring by non-mechanical means a liquid chemical from a source to a pressure vessel through a delivery conduit, wherein the pressure vessel has an interior surface; (b) providing a flexible liquid metering device disposed within the pressure vessel, the metering device having an interior and an interior surface and an exterior and an exterior surface; the liquid chemical occupying at least a portion of the space being defined by at least a portion of the metering device external surface and at least a portion of the pressure vessel interior surface, or by at least a portion of the metering device internal surface; and (c) delivering a pressurized gas into the pressure vessel so as to contact the other of the interior or exterior surface of the metering device that defines the space, whereby the liquid chemical is forced out of the pressure vessel by the metering device to an end use station.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] The objects and advantages of the invention will become apparent from the following detailed description of the preferred embodiments thereof in connection with the accompanying drawings, in which like numerals designate like elements, and in which:

[0018] **FIG. 1** is a schematic drawing of an exemplary system for transferring and delivering a liquid chemical from a source to an end use station in accordance with one aspect of the invention;

[0019] **FIG. 2** is a schematic drawing of an exemplary chemical source container and high-pressure gas supply module in accordance with the invention;

[0020] **FIG. 3** is a schematic drawing of an exemplary balloon for use in the systems in accordance with the invention; and

[0021] **FIG. 4** is a schematic drawing of an exemplary pressure vessel and bellows for use in the systems in accordance with the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

[0022] The present invention will be discussed with reference to **FIG. 1**, which illustrates an exemplary system **1** for transferring and delivering a liquid chemical from a source to an end use station in accordance with one aspect of the invention. As used herein, the term "liquid chemical" is intended to cover slurries as well as conventional liquid-state materials. Typical liquid chemicals used in the semiconductor manufacturing industry include, for example, ammonium hydroxide, sodium hydroxide, ammonium fluoride, hydrochloric acid, hydrofluoric acid, nitric acid, sulfuric acid, phosphoric acid, acetic acid, hydrogen peroxide, isopropyl alcohol, tetramethylammonium hydroxide, cyclohexanone, PGMEA (1-methoxy-1-methylethyl acetate), photoresists, dopants such as $POCl_3$ (phosphorus oxychloride) and BBr_3 (boron tribromide), chemical slurries, deionized water, and mixtures of the above or different chemicals.

[0023] The system **1** includes a chemical source container **3** for supplying the liquid chemical to one or more pressure vessels **5**a, **5**b, and from the pressure vessels to one or more end user stations **7**a, **7**b, for example, a semiconductor manufacturing processing station. The chemical source container **3** is typically a bulk storage container and can be of any size and shape. To prevent contamination of the chemical contained therein, the chemical source container is constructed of a material compatible with the chemical contained therein. Typical materials include, for example, TEFLON, high density polyethylene, polypropylene, stainless steel, or carbon steel coated with a plastic material. The chemical source container **3** includes a liquid chemical outlet **9** for transfer of the chemical through the system, and is typically open to ambient, usually through a small conduit with a filter (not shown). The chemical source container is typically disposed in the vicinity of the pressure vessels **5***a*, **5***b*, for example from about 0.1 to 50 meters, preferably from about 1 to 10 meters, from the pressure vessels.

[**0024**] A non-mechanical means is provided for transferring the liquid chemical from the source container **3** to the pressure vessels **5***a*, **5***b*. By use of a non-mechanical means, problems associated with the use of mechanical devices such as pumps for chemical transfer can be avoided. Such problems include, for example, contamination of the liquid chemical and loss of productivity due to downtime for scheduled and non-scheduled maintenance of the mechanical device. Without limitation, the non-mechanical means can take the form, for example, of a gravity feed structure for supplying the chemical to the pressure vessels **5***a*, **5***b*, wherein the source container **3** is disposed at an elevated position with respect to the pressure vessels.

[**0025**] **FIG. 2** illustrates a further exemplary structure for the non-mechanical means for transferring the liquid chemical from the source container to the pressure vessels. A high-pressure gas supply module **11** is provided to transfer the chemical from the source container **3** to the pressure vessels. The gas supply module **11** can include a pressurized gas supply conduit **13** connected to a pressurized gas supply source, and an isolation valve V1 in the conduit. The gas can be an inert gas, for example, nitrogen, helium, or purified dry air, preferably at a pressure of from 1 to 50 psig. Alternatively, the pressurized gas can be a material which reacts with the liquid in the source container to form a desired chemical. For example, the pressurized gas can be ammonia, hydrogen fluoride, or hydrogen chloride. When combined with a liquid chemical, for example, deionized water, chemicals such as ammonium hydroxide, hydrofluoric acid and hydrochloric acid, respectively, can be formed. In such a manner, ammonium fluoride can be formed by combining aqueous hydrofluoric acid and pressurized ammonia gas, or aqueous ammonium hydroxide and pressurized hydrogen fluoride gas.

[**0026**] A gas release conduit **15** with an isolation valve V2 branches off from the gas supply conduit **13**. When transferring the chemical from the source container **3** to the pressure vessels **5***a*, **5***b*, isolation valve V2 is closed and isolation valve V1 is opened. The pressurized gas is thus introduced to the source container, and the resulting pressure allows the chemical to be transferred to the pressure vessels. When flow of the liquid chemical to the pressure vessels is to be stopped or the source container **3** is empty, the pressurized gas supply is stopped by closing isolation valve **V1**, and the vent line **15** can be opened by opening valve **V2** to release the pressurized gas. The released gas is introduced into a scrubber (not shown) to recover or detoxify the gas. When a reactive gas is used, the gas may not be released when the source container **3** is empty. The gas may be consumed by reacting with refilled liquid chemical. In any case, the source container **3** can then be refilled on site or replaced with another source container. To monitor the amount of chemical contained inside the source container, a weighing scale can be set beneath the source container. Ultrasonic level sensors can also be used for monitoring purposes by mounting at either the top, bottom and/or side of the container. Capacitive or optical level sensors can also be employed by adding other parts, for example, a side tube or dip tube.

[**0027**] The pressure vessels **5***a*, **5***b* are preferably cylindrical in shape and constructed of a metal and/or plastic material, for example, stainless steel (e.g., 304L or 316L stainless steel), carbon steel, TEFLON, high density polyethylene, or the like. Depending on the chemical to be delivered, a metal vessel having its interior wall coated with either TEFLON, high-density polyethylene, or polypropylene can be used to ensure chemical compatibility and prevention of impurity leaching from the metal surfaces. If desired, the outer surface of the pressure vessel can be strengthened, for example, by wrapping it with a layer of polyvinyl chloride (PVC).

[**0028**] The interior of the pressure vessels **5***a*, **5***b* includes an interior space **17***a*, **17***b* for containing the liquid chemical. A flexible flow-metering device **19***a*, **19***b* for controlling the flow of liquid chemical from the pressure vessel to the end user stations is provided in each of the pressure vessels. The metering device can take the form, for example, of a balloon having a flexible and non-expandable wall such as shown in **FIGS. 1 and 3**, or a bellows **21** such as shown in **FIG. 4**. The metering device **19***a* or **19***b* has an interior and an interior surface and an exterior and an exterior surface. A space defined by at least a portion of the metering device external surface and at least a portion of the pressure vessel interior surface is adapted to receive the liquid chemical. While the following description relates to the aforementioned embodiment, in an alternative embodiment, the liquid chemical can be contained within the metering device such that the space for receiving the liquid chemical is defined by the metering device internal surface.

[**0029**] Each pressure vessel **5***a*, **5***b* has a liquid chemical inlet/outlet **23***a*, **23***b* for transfer of the liquid chemical into and out of the vessel, and a pressurized inert gas inlet/outlet **25***a*, **25***b* for introducing/venting a pressurized inert gas into/out of the metering device. The liquid chemical inlet/outlet **23***a*, **23***b* and inert gas inlet/outlet **25***a*, **25***b* are preferably disposed on opposite sides of the vessel **5***a*, **5***b*. An additional opening **27***a*, **27***b* in the pressure vessel **5***a*, **5***b* can be provided in an upper portion, for example, in an upper side of the pressure vessel for liquid level monitoring purposes.

[**0030**] **FIG. 3** illustrates a preferred embodiment of a balloon **19** which can be used as the flow-metering device. The balloon is preferably substantially cylindrical in shape although other shapes can be employed, and preferably matches with the interior space of the pressure vessel in which the bag is to be contained. The balloon is preferably constructed of a flexible material such as a plastic film or rubber sheet, with a plastic film being particularly preferred. Exemplary plastic materials for the balloon include polypropylene, polyethylene, TEFLON, and combinations thereof. Generally, any plastic material that can be made into a thin film and is compatible with the liquid chemical can be used for the balloon. As the balloon is not subjected to pressure during use, the thickness of the plastic film can be minimized for better flexibility and durability of the balloon. The thickness of the balloon film is typically from about 1 to 50 mil, preferably from about 3 to 10 mil.

[0031] When the balloon is constructed from plastic film, one or more pieces of the film are preferably thermally welded together along the balloon edges, with the welding temperature depending on the particular film material. For most plastic materials, a suitable welding temperature is in the range of from about 300 to 750° C. The body of the balloon **29** can alternatively be blow-molded in order to eliminate or reduce the amount of welding described above. For example, a film tube can be formed and then welded together at the top and bottom to form the balloon.

[0032] A hole **31** is cut near the top edge of the balloon at one side to receive a gas inlet **33**. The gas inlet **33** allows for introduction of an inert gas into and out of the bag and is useful for purposes of mounting the balloon in the pressure vessel. The gas inlet **33** is typically a small piece of pipe **35** with a flange **37** constructed preferably of the same material as the plastic film. Connection of the gas inlet **33** to the main body of the balloon is preferably accomplished by thermally welding the inlet to the main body. The gas inlet and the flange pass through the hole **31** into the plastic balloon, with the top surface of the flange **37** resting on the inner surface of the balloon. Hence, a small portion of the film extends onto the flange surface and can be thermally welded to the flange. The balloon **19** can be mounted inside the vessel by welding the gas inlet to the gas opening of the pressure vessel. Other methods such as screwing the gas inlet pipe **35** into the pressure vessel can be employed for mounting the balloon inside the vessel.

[0033] **FIG. 4** illustrates an exemplary embodiment of pressure vessel **5** with a bellows **21** as the flow-metering device. The bellows is typically constructed from polypropylene, polyethylene, TEFLON, stainless steel, carbon steel or other metal coated with a material compatible with the chemical being distributed, for example, polypropylene, polyethylene, or TEFLON. Suitable bellows are commercially available, for example, from Alloy Bellow and Precision Welding Inc. (Cleveland, Ohio.) and Palatine Precision Ltd. (Rochester, England), or can be easily customized.

[0034] The pressure vessel has a flange **39** at the upper end. A cover **41** is provided that includes the pressurized inert gas inlet/outlet **25** for introducing/venting the pressurized inert gas into/out of the bellows. While illustrated as being dome-shaped, the top cover **41** can take other forms, for example, flat disk-shaped with an inert gas inlet/outlet at its center. The bellows has a flexible body **43** that can stretch and contract along its axial direction and is completely sealed at a bottom end **45**, and a neck **47** and a flange **49** for mounting the bellows in the pressure vessel. Preferably, the flange **49** of the bellows is sandwiched between the main body flange **39** and the top cover flange **51**, which can be fastened together with bolts **53** and nuts **55**. The bellows preferably includes o-rings **57** set below and above the flange **49** to adequately seal the pressure vessel. The bellows is caused to expand, i.e., lengthen, during chemical delivery, and to contract, i.e., shorten, when the pressure vessel is refilled.

[0035] In accordance with a preferred aspect of the invention, the pressure vessels **5**_a_, **5**_b_ are provided for controllably metering the liquid chemical to one or more end user stations **7**_a_, **7**_b_. A plurality of pressure vessels is preferably provided to ensure continuous and smooth distribution of the chemical to the end user. Typically, one of the vessels **5**_a_, **5**_b_ is in a mode of delivering the chemical while another of the vessels is in a chemical filling or standby mode. The chemical supply module **59** as shown in **FIG. 1** includes a series of conduits and valves through which the liquid chemical flows. When filling the pressure vessel **5**_a_, the chemical flows from the source container into the pressure vessel through conduits **61**, **63**_a_ and **65**_a_, with valves V3_b_ and V4_a_ being closed and valve V3_a_ being open. Similarly, when filling the pressure vessel **5**_b_, the chemical flows into the pressure vessel from the source container through conduits **61**, **63**_b_ and **65**_b_, with valves V3_a_ and V4_b_ being closed and valve V3_b_ being open. When delivering the chemical to the end use stations **7**_a_, **7**_b_ from the pressure vessel **5**_a_, the chemical flows from the pressure vessel **5**_a_ through conduits **65**_a_, **67**_a_ and **69**, with valves V3_a_ and V4_b_ being closed and valve V4_a_ being open. When delivering the chemical to the end use stations **7**_a_, **7**_b_ from the pressure vessel **5**_b_, the chemical flows from the pressure vessel through conduits **65**_b_, **67**_b_ and **69**, with valves V3_b_ and V4_a_ being closed and valve V4_b_ being open.

[0036] A side tube **71**_a_, **71**_b_ constructed of a plastic material such as TEFLON, polypropylene, or polyethylene, or a glass or quartz, can be provided for monitoring the level of the chemical in the pressure vessels. The tube can be connected at one end to the conduit **65**_a_, **65**_b_ which connects to the liquid chemical inlet/outlet **23**_a_, **23**_b_ of the pressure vessels and at an opposite end to the opening **27**_a_, **27**_b_ at an upper portion, for example, the top side of the pressure vessels. One or more level sensors **73**_a_, **73**_b_ can be mounted on the side tube **71**_a_, **71**_b_ to monitor one or more of, for example, low-low, low, high, and high-high liquid levels. The level sensors can be, for example, ultrasonic, optical, or capacitive-type sensors. Suitable sensors are available, for example, from OMRON (Schaumburg, Ill.).

[0037] To effect distribution of the liquid chemical from the pressure vessels **5**_a_, **5**_b_, a gas module **75**_a_, **75**_b_ is provided to supply a high pressure gas to the flow-metering device **19**_a_, **19**_b_ in the pressure vessels. Filling of the pressure vessels is accompanied by venting of gas from the metering devices with the gas module. The high pressure gas is preferably an inert gas, for example, nitrogen, helium, or dry air, typically at a pressure of from about 1 to 10 bars, preferably from about 3 to 8 bars. The exemplary gas module includes a conduit **77**_a_, **77**_b_ connected at one end to a high pressure gas source and at another end to the gas inlet **33**_a_, **33**_b_ of the flow-metering device. An isolation valve V5_a_, V5_b_ is provided in the conduit **77**_a_, **77**_b_. A conduit **79**_a_, **79**_b_ with isolation valve V6_a_, V6_b_ connects the gas conduit **77**_a_, **77**_b_ to a vent system through a conduit **81**_a_, **81**_b_.

[0038] When pressurization of the pressure vessels **5**_a_, **5**_b_ is required, isolation valve V5_a_, V5_b_ is opened and isolation valves V6_a_, V6_b_ and V7_a_, V7_b_ are closed. This permits the high pressure gas to flow through the conduit **77**_a_, **77**_b_ into the flow-metering device **19**_a_, **19**_b_. Pressurization of the flow-metering device causes the device to expand towards the bottom of the pressure vessel, thus exerting pressure on the liquid chemical and forcing it out of the pressure vessel through the conduits **65**a, **65**b.

[**0039**] When release of the gas inside the flow-metering device is desired, the isolation valve V**5**a, V**5**b is closed and the isolation valve V**6**a, V**6**b is opened. The gas is released from the metering device through a portion of conduit **77**a, **77**b, and through conduits **79**a, **79**b and **81**a, **81**b to a vent system. During the process of filling the pressure vessels with the liquid chemical, the isolation valves V**6**a, V**6**b and V**7**a, V**7**b are open to allow the chemical to be filled in the vessel at ambient pressure.

[**0040**] Operation of the system in accordance with the invention is preferably automatically controlled. Suitable control means are known to persons skilled in the art, and include, for example, one or more programmable logic controllers (PLCs) or microprocessors connected with the valves and level sensing devices, as well as any other desired flow control devices.

[**0041**] While the invention has been described in detail with reference to specific embodiments thereof, it will be apparent to one skilled in the art that various changes and modifications can be made, and equivalents employed, without departing from the scope of the appended claims. For example, the flow-metering-device can, if desired, be used in a manner opposite to that described above by filling the interior of the device with the liquid chemical and pressurizing the space inside the pressure vessel outside of the device. In this manner, the high-pressure gas will cause the flow-metering-device to contract, forcing the liquid chemical out of the device for chemical distribution.

What is claimed is:

1. A system for transferring and delivering a liquid chemical from a source to an end use station, comprising:

(a) a pressure vessel connected to a liquid chemical source by a delivery conduit, the pressure vessel having an internal surface;

(b) a non-mechanical means of transferring the liquid chemical from the source through the delivery conduit to the pressure vessel;

(c) a flexible liquid metering device disposed within the pressure vessel, the metering device having an interior and an interior surface and an exterior and an exterior surface;

(d) a space adapted to receive the liquid chemical, the space being defined by at least a portion of the metering device external surface and at least a portion of the pressure vessel interior surface, or by at least a portion of the metering device internal surface; and

(e) a pressurized gas conduit connected to a pressurized gas source for delivering the pressurized gas into the pressure vessel so as to contact the other of the interior or exterior surface of the metering device that defines the space, whereby the liquid chemical is forced out of the pressure vessel by the metering device to an end use station.

2. The system according to claim 1, wherein the pressurized gas conduit is connected to deliver the pressurized gas into the pressure vessel so as to contact the interior surface of the metering device.

3. The system according to claim 1, wherein the non-mechanical means of transferring the liquid chemical comprises a gravity feed structure, and wherein the liquid chemical source is contained in a container at an elevated height with respect to the pressure vessel.

3. The system according to claim 1, wherein the non-mechanical means of transferring the liquid chemical source comprises means for pressurizing the liquid chemical source with a pressurized gas.

4. The system according to claim 3, wherein the pressurized gas is an inert gas.

5. The system according to claim 3, wherein the pressurized gas is a reactive gas.

6. The system according to claim 1, wherein a plurality of pressure vessels connected in parallel is used.

7. The system according to claim 1, wherein the metering device is a balloon.

8. The system according to claim 7, wherein the balloon is constructed of a material selected from the group consisting of TEFLON, polypropylene and polyethylene.

9. The system according to claim 1, wherein the metering device is a bellows.

10. The system according to claim 9, wherein the bellows is constructed of a material selected from the group consisting of polypropylene, polyethylene, TEFLON and stainless steel.

11. The system according to claim 1, further comprising:

a first isolation valve in the pressurized gas conduit;

a vent conduit with a second isolation valve connected to a vent system at one end, and to an upper portion of the pressure vessel at another end; and

a connecting conduit with a third isolation valve connected to the pressurized gas conduit and the vent conduit.

12. A method of transferring and delivering a liquid chemical from a source to an end use station, comprising:

(a) transferring by non-mechanical means a liquid chemical from a source to a pressure vessel through a delivery conduit, wherein the pressure vessel has an interior surface;

(b) providing a flexible liquid metering device disposed within the pressure vessel, the metering device having an interior and an interior surface and an exterior and an exterior surface; the liquid chemical occupying at least a portion of the space being defined by at least a portion of the metering device external surface and at least a portion of the pressure vessel interior surface, or by at least a portion of the metering device internal surface; and

(c) delivering a pressurized gas into the pressure vessel so as to contact the other of the interior or exterior surface of the metering device that defines the space, whereby the liquid chemical is forced out of the pressure vessel by the metering device to an end use station.

13. The method according to claim 12, wherein the pressurized gas is delivered into the pressure vessel so as to contact the interior surface of the metering device.

14. The method according to claim 12, wherein the non-mechanical means of transferring the liquid chemical source comprises means for pressurizing the liquid chemical source with a pressurized gas.

15. The method according to claim 14, wherein the pressurized gas is an inert gas.

16. The method according to claim 14, wherein the pressurized gas is a reactive gas.

17. The method according to claim 12, wherein a plurality of pressure vessels connected in parallel is used.

18. The method according to claim 12, wherein the metering device is a balloon.

19. The method according to claim 18, wherein the balloon is constructed of a material selected from the group consisting of TEFLON, polypropylene and polyethylene.

20. The method according to claim 12, wherein the metering device is a bellows.

21. The method according to claim 20, wherein the bellows is constructed of a material selected from the group consisting of polypropylene, polyethylene, TEFLON and stainless steel.

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