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(54) **PUMP PULSATION DAMPENING ATTACHMENT AND METHOD FOR DAMPENING PUMP PULSATIONS**

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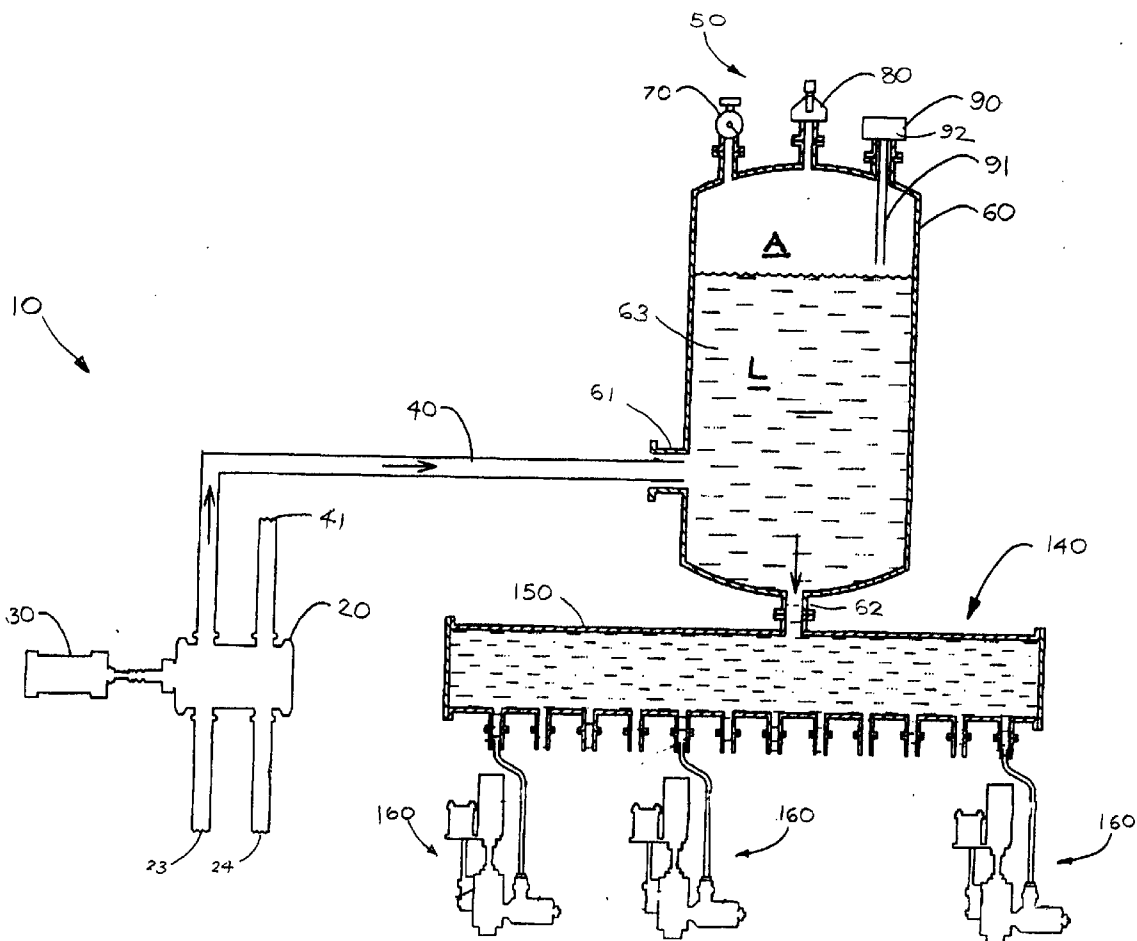
(57) **ABSTRACT**

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A pump delivery system including a pump mechanism for delivering liquids under pressure while also producing a pulsating output during operation, and a pump pulsation dampening attachment for dampening the pulsating output of the pump mechanism. The pump pulsation dampening assembly includes a pressurized vessel having an interior surface defining a chamber for receiving the liquid from the pump mechanism, the chamber also containing a pocket of pressurized air therein for absorbing the pulsating output generated by the pump mechanism.

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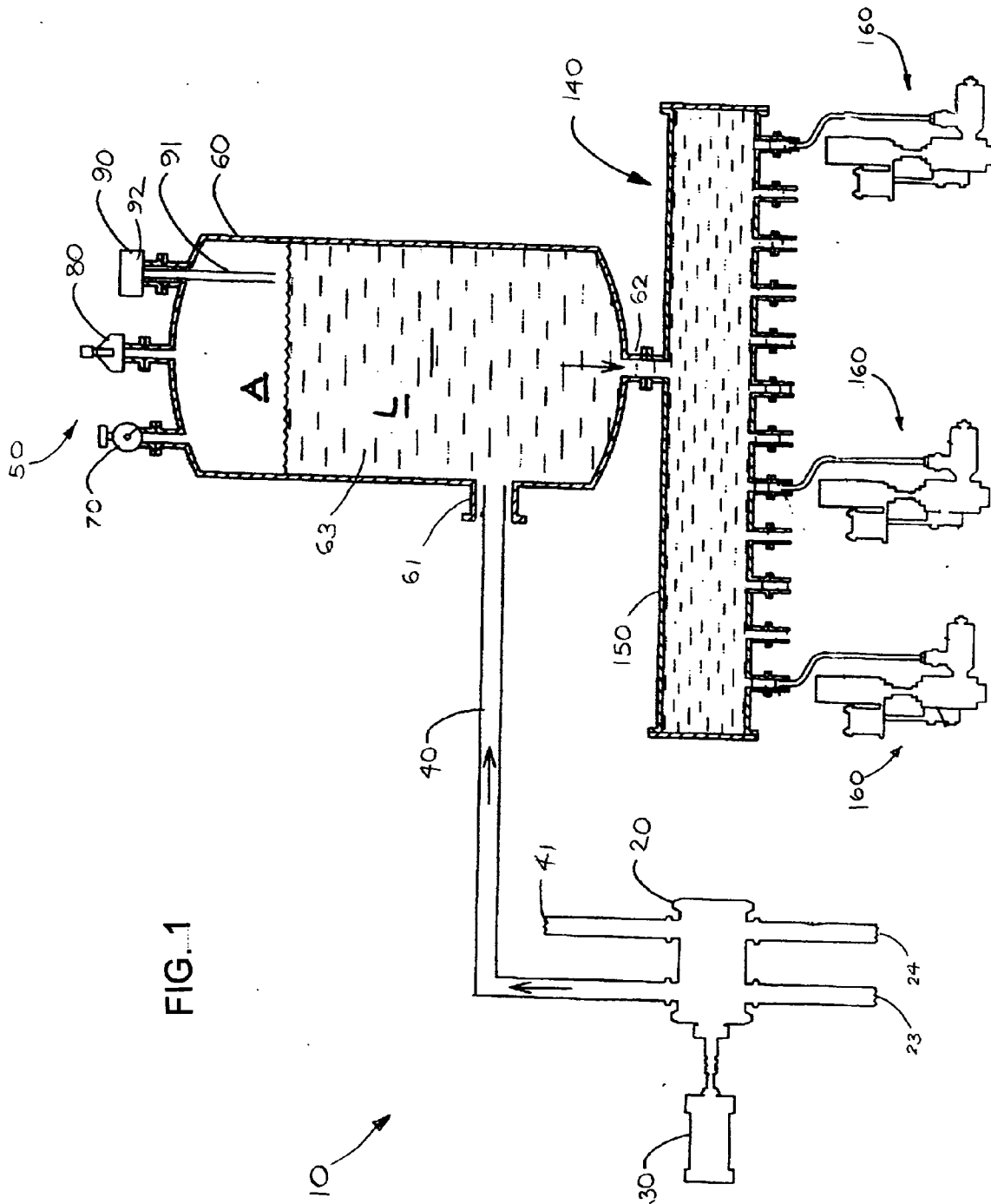


FIG. 1

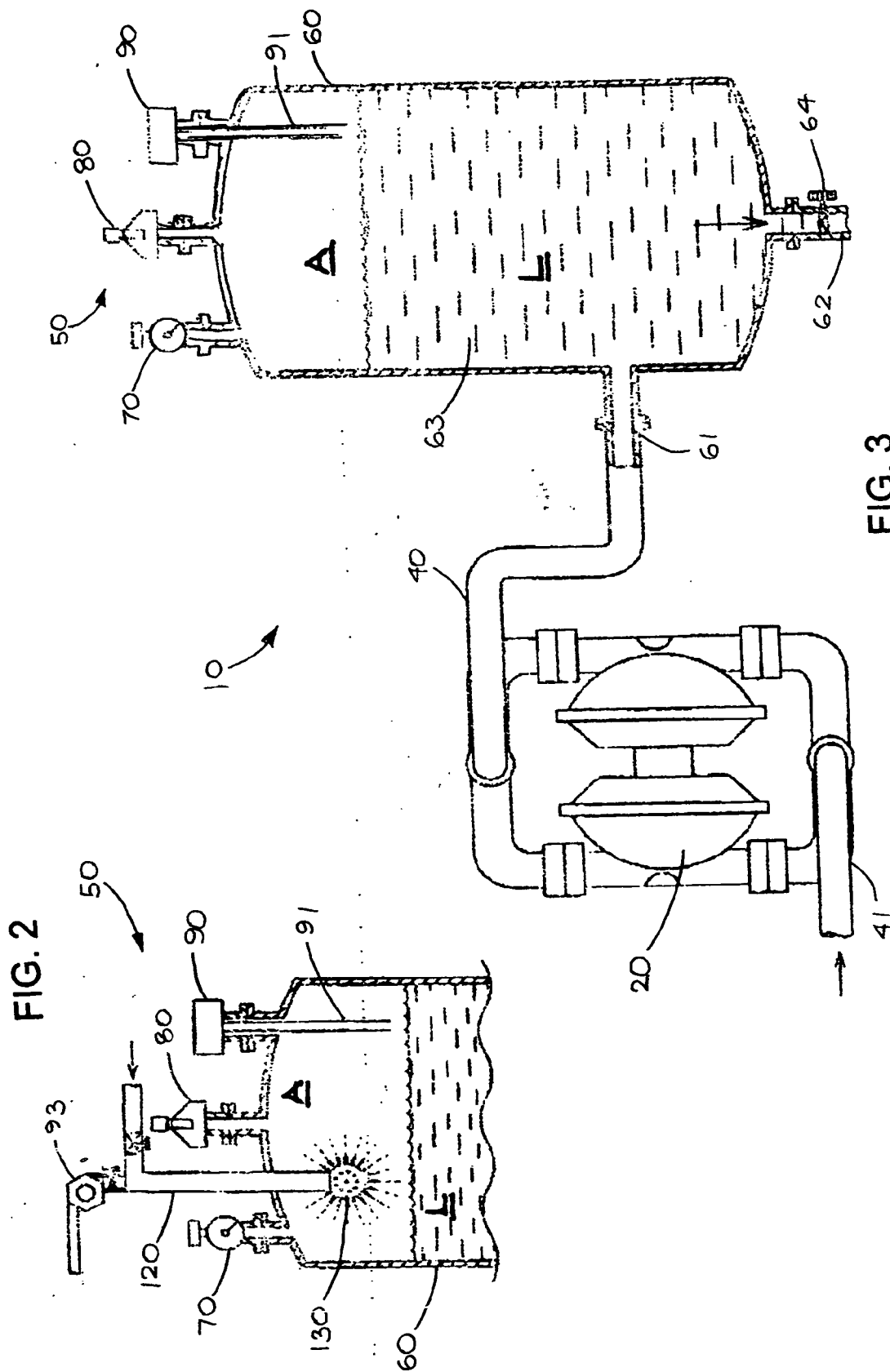


FIG. 3

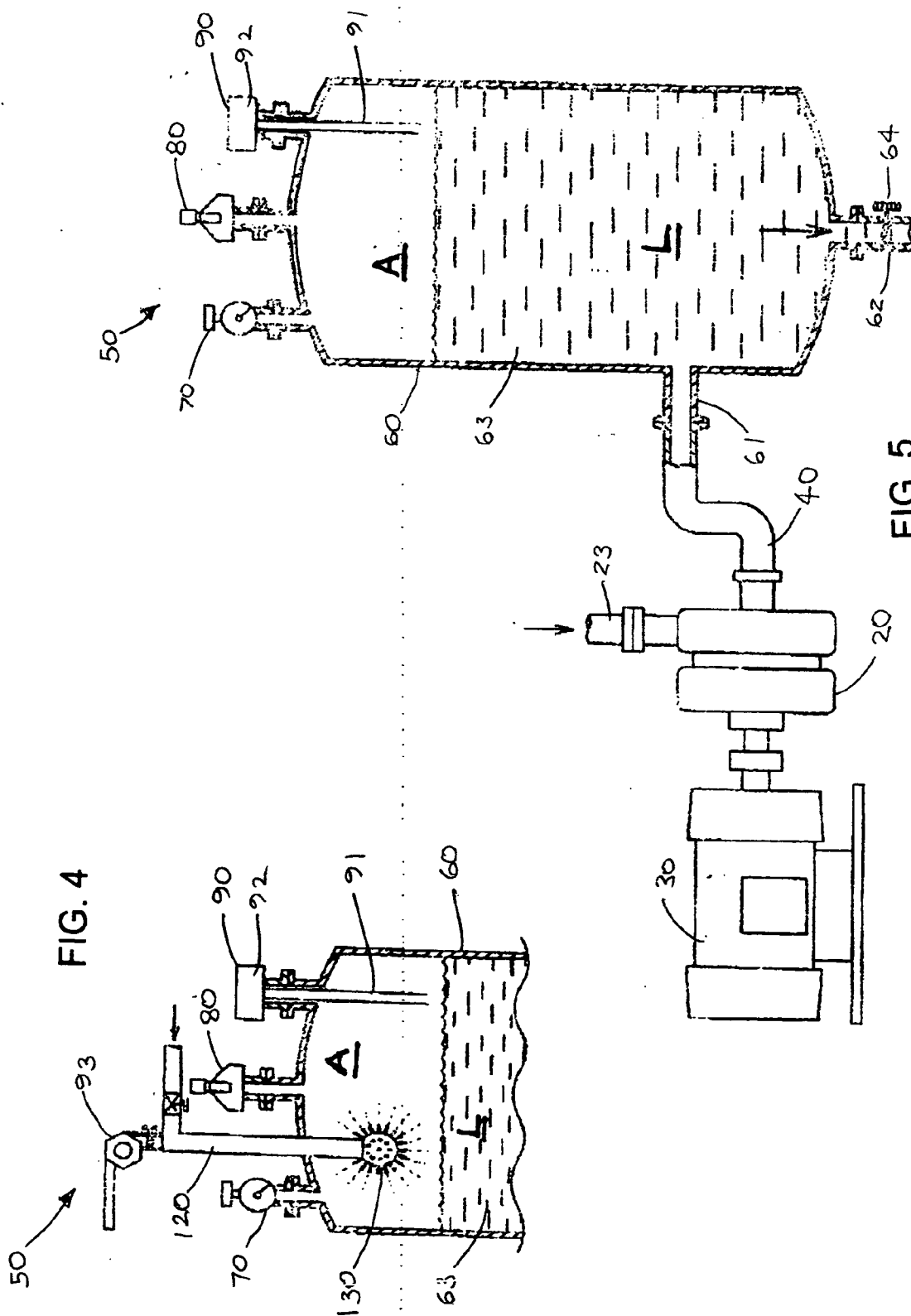


FIG. 4

FIG. 5

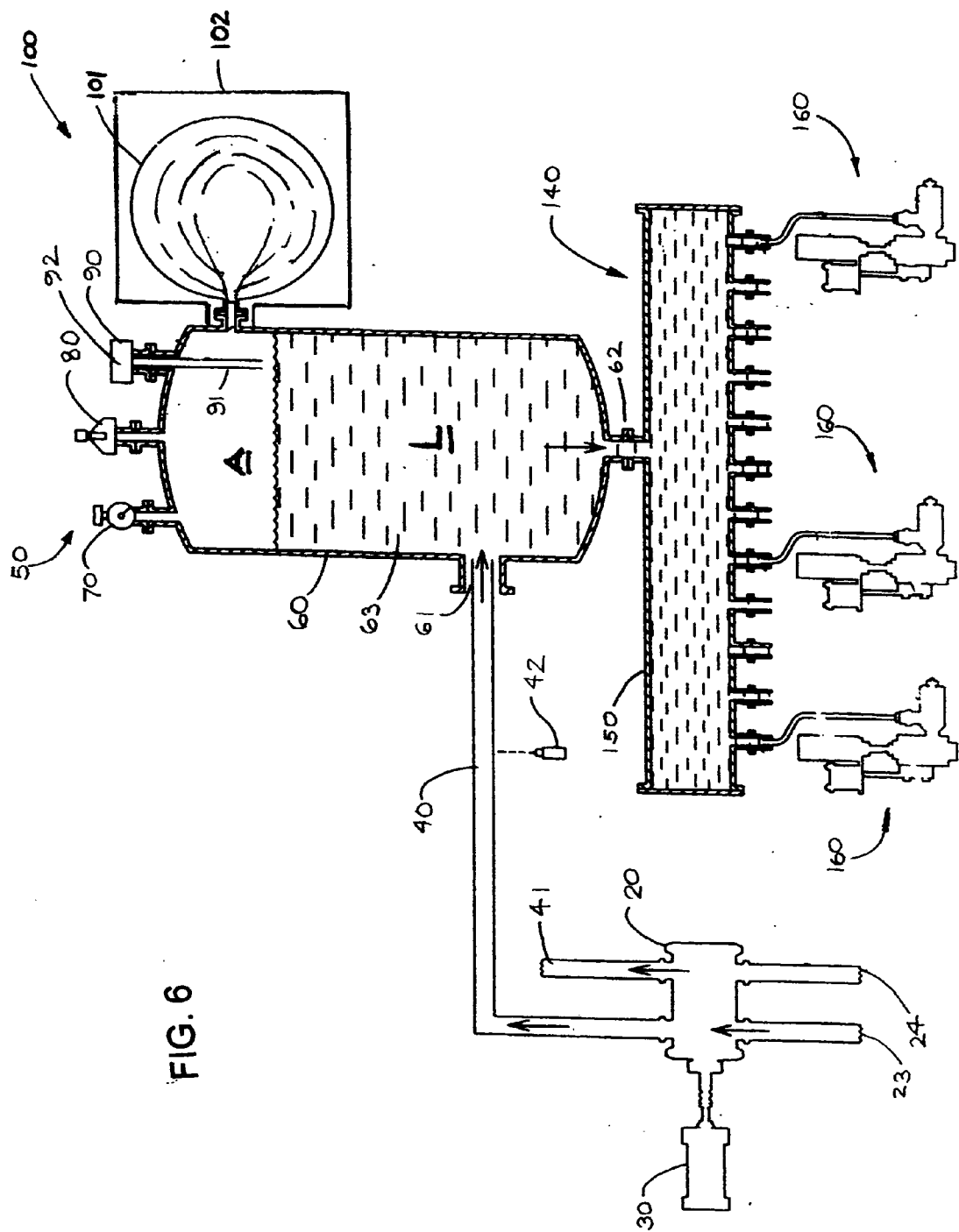


FIG. 6

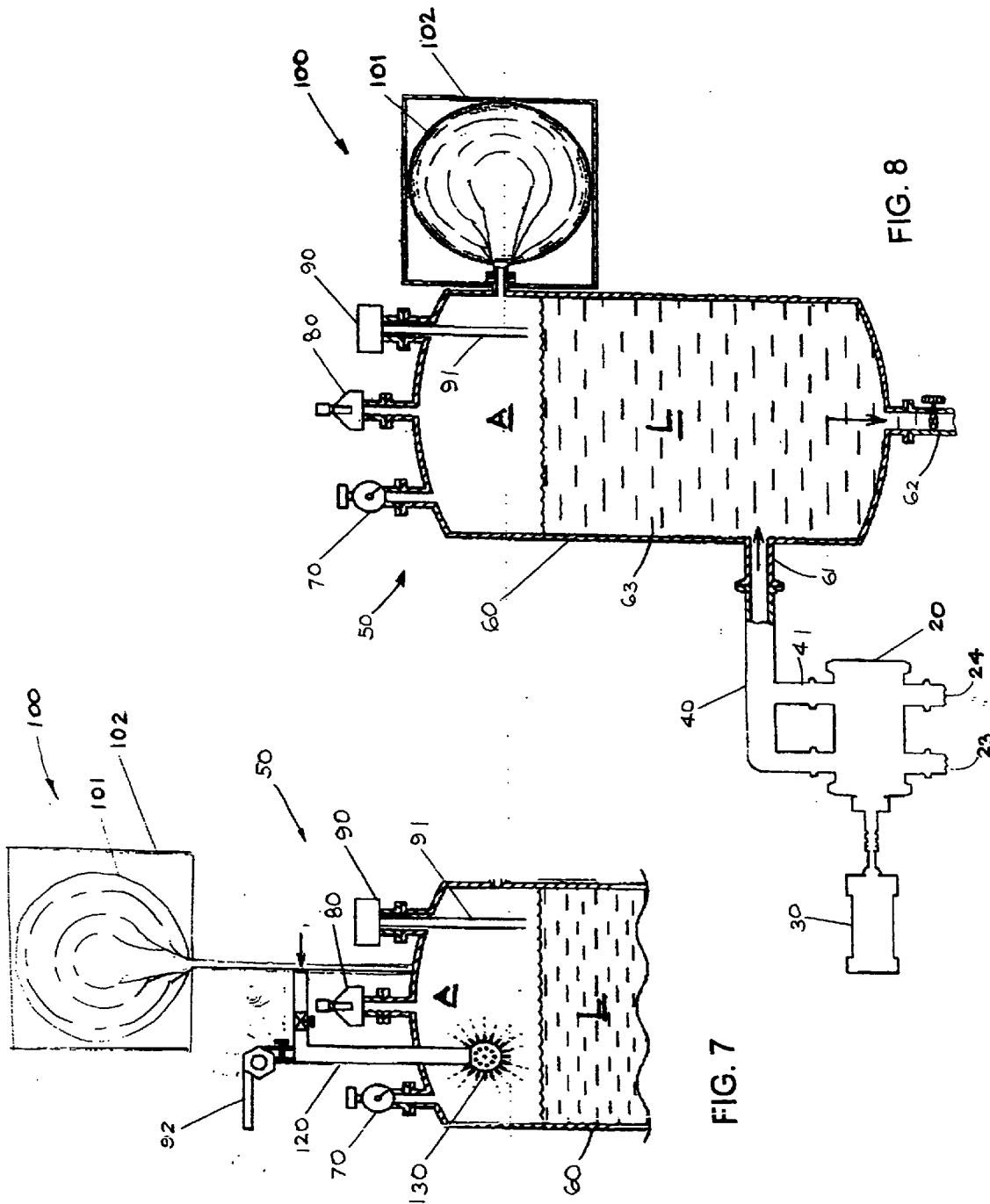
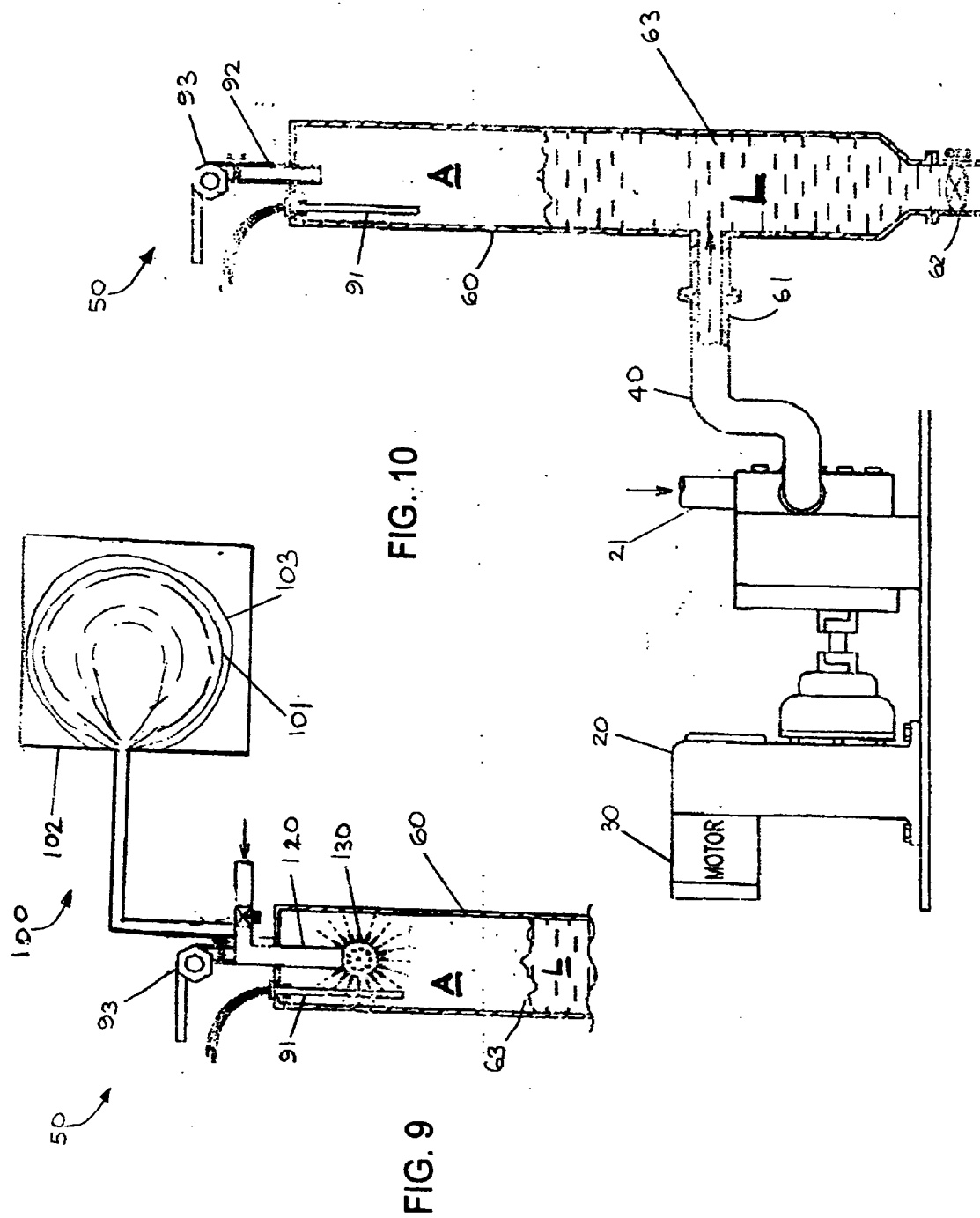


FIG. 7

FIG. 8



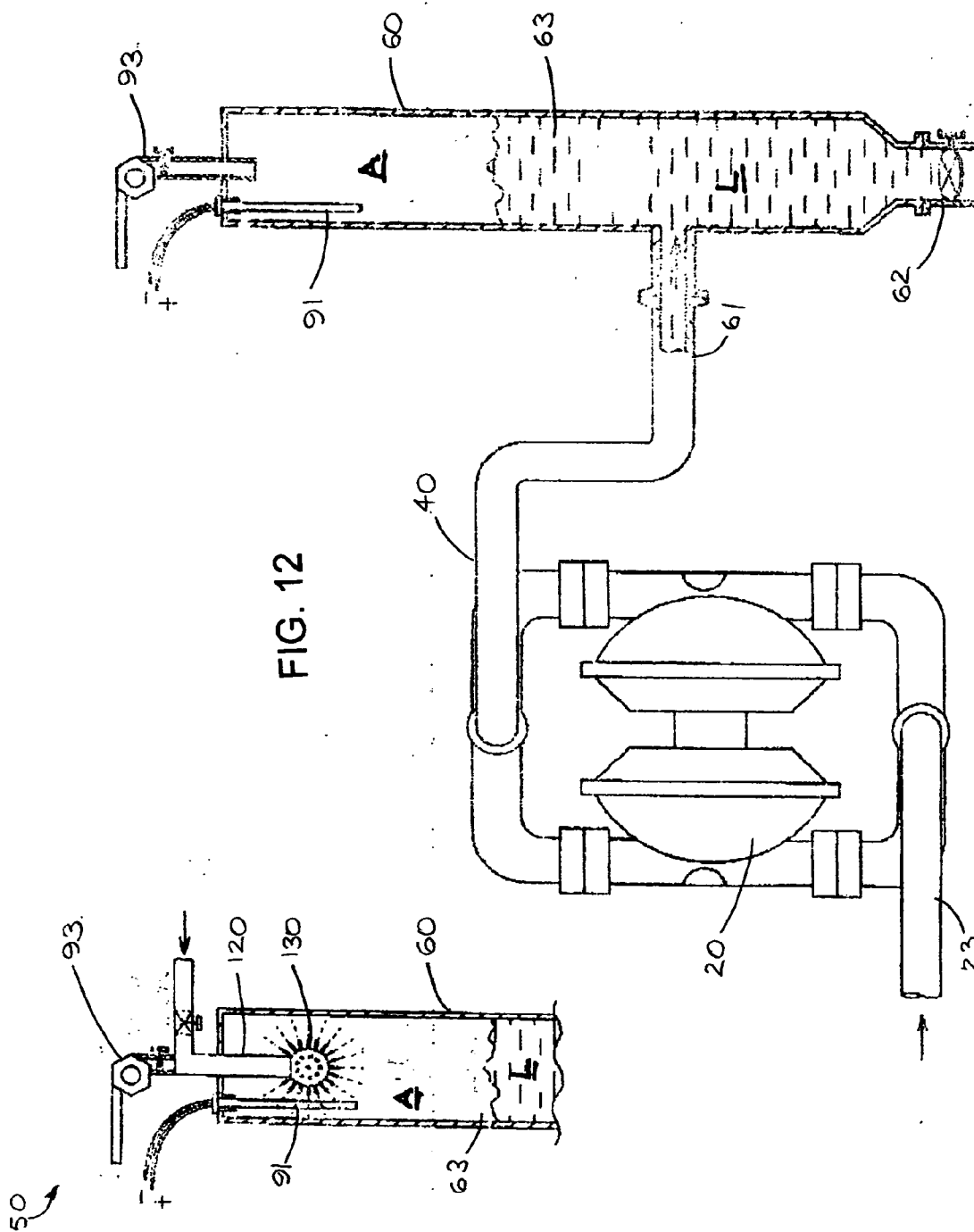


FIG. 12

FIG. 11

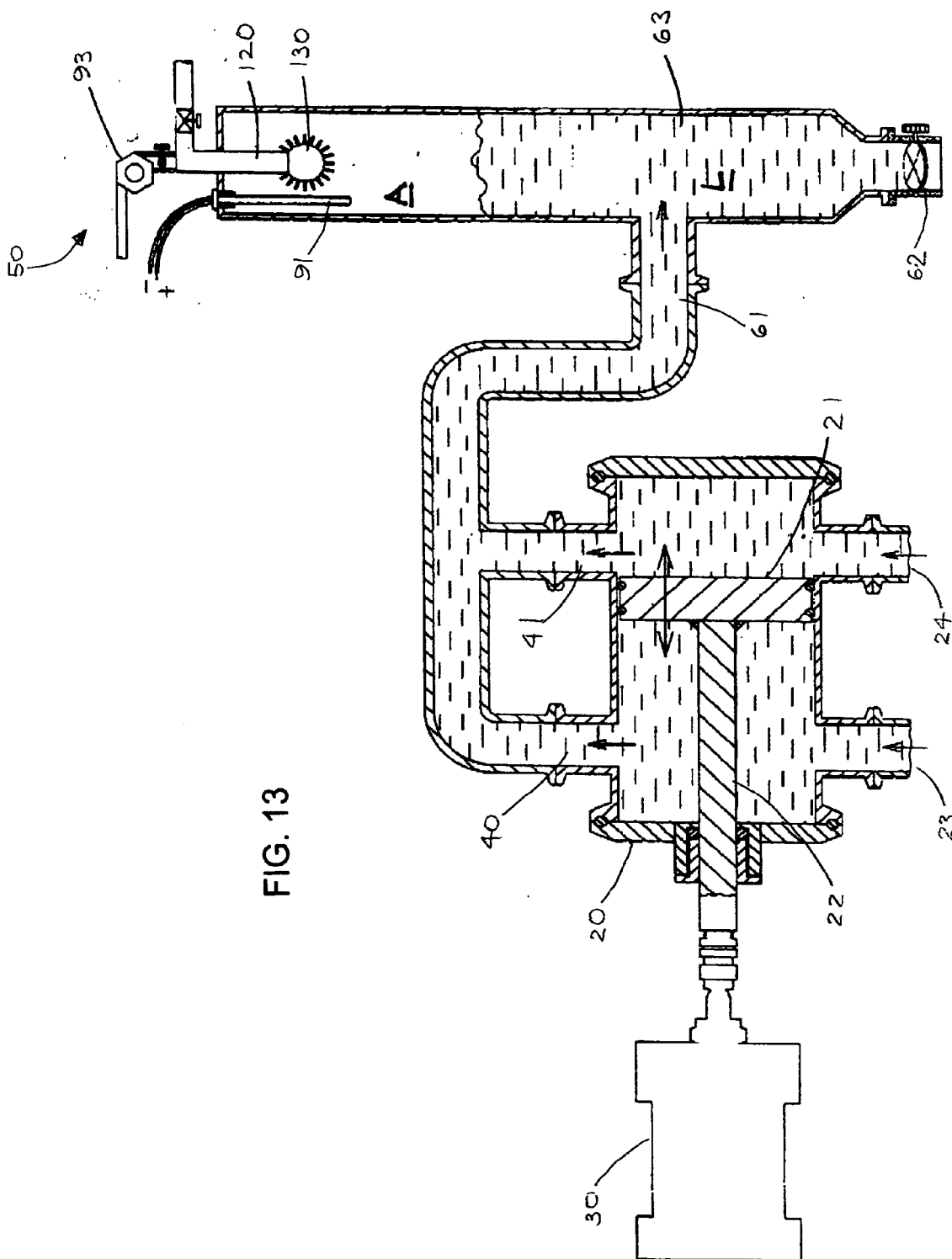


FIG. 13

**PUMP PULSATION DAMPENING ATTACHMENT  
AND METHOD FOR DAMPENING PUMP  
PULSATIONS**

**BACKGROUND OF THE INVENTION**

**[0001]** 1. Field of the Invention

**[0002]** This invention relates generally to a pump delivery system adaptable to dampen the pulsating flow or hydraulic shock caused as result of the intermittent nature or the idle period of the pump mechanism and also adaptable for use in sanitary filling operations. More particularly, the invention relates to a hydraulic shock absorbing attachment adaptable to substantially dampen pulsations resulting from the operation of various pumps including constant pressure pumps for the high-speed delivery of precisely measurable quantities of liquids.

**[0003]** 2. Description of the Related Art

**[0004]** A wide variety of industrial applications, especially in the pharmaceutical and food processing industries require high-speed fluid metering and pumping systems capable of delivering precisely measured quantities of fluids at accurate flow rates to various locations. Sanitary filling operations require that sanitary pumping systems provide a constant pressure in order to deliver precise quantities of liquid food products of varying consistencies, viscosities, densities, etc. such as milk, yogurt, cream, cream cheese, etc. to fill heads for the subsequent metered dispensation into containers. Such sanitary pump systems are adapted to operate under high speed pumping operations in pressure ranges of 400 pounds per square inch (psi) or greater and pumping cycles in the range of about 20-200 cycles per minute and preferably 60-160 cycles per minute to provide constant flow. Accordingly, in such operations, precise and accurate fluid delivery is critical.

**[0005]** Moreover, such sanitary filling operations must meet the performance requirements established by the U.S. Food and Drug Administration (FDA), which require that machines used to fill containers with liquid food or drug products must be sterilizable, and readily cleaned of liquid products which might be trapped in cavities within machine parts, and thereby providing a growth media for microbes. Accordingly, a goal in the design and construction of production line filling machines for liquid food products is that to provide an attachment as well as components suitable for Cleaning-In-Place (C.I.P.), with no or minimal disassembly of machine components required.

**[0006]** Heretofore, pump delivery systems for pumping fluids to various sources, are known in the art. Many of such prior art systems utilize various pump mechanisms to carry out the delivery operations, such as piston pumps, diaphragm pumps, positive displacement pumps, centrifugal pumps and the like. Prior art systems of the aforementioned types typically deliver such fluids under constant pressure in an effort to achieve consistent flow rates. While these prior art systems are sometimes adequate for certain applications, precise and accurate flow rates in such systems are difficult to achieve due to the pulsing, surging, or hydraulic shock generated by the output of the pump mechanism, which also must be comparable with CIP facilities. For example, positive displacement pumps typically generate significant pressure surges due to the rapid acceleration and deceleration of

the liquid during the sinusoidal cycle of the pump. Such pulsing, surging or otherwise hydraulic shock is undesirable since it typically results in hydraulic hammer in process lines, large pressure fluctuations, excessive wear and increased cost of maintenance of pumps and instruments, inaccurate flow rates during delivery operations, which results in increased production costs production time.

**[0007]** Many prior art pump delivery systems have attempted to dampen, suppress, reduce or otherwise minimize the surging or pulsing output generated by the associated pump mechanism during delivery operations. For example, U.S. Pat. No. 5,806,716 to Vogt provides a pressurized tank that offers high speed, mass production filling of containers with a mass flow sensor mounted on a means for dampening vibration to ensure accurate measurement of dispensed fluids. The pressurized tank includes pressures regulators sensors and a computer for controlling its operation. The pressurized tank of Vogt, however, is not adaptable for standard pumps with mechanical pumps such as cylinders, as they are found to be unsuitable since they permit the occurrence of undesirable contaminates. Accordingly, the tank in Vogt cannot accommodate a wide range of pumps and pumping systems in which pump pulsating output is variable. The tank also lacks a sensing mechanism for monitoring and adjusting the air-to-liquid ratio in the dampening chamber and is not sized to correspond to the duration and intensity level of the pulsating output.

**[0008]** U.S. Pat. No. 5,730,324 to Shannon et al. provides a post-mixed beverage dispensing system from a pressurized tank that is pressurized by a pressurized tank pump. In order to overcome the problems of the reduction of pressure associated with the simultaneous multiple dispensing and/or rapid sequential dispensing operations, the pressurized tank is maintained at a constant pressure by pumping syrup into the tank and venting the tank in order to prevent over-pressurization. The tank of Shannon, however, does not include a sensing mechanism for monitoring and adjusting the air-to-liquid ratio in the dampening chamber and is not sized to correspond to the duration and intensity level of the pulsating output. The tank is also not adaptable for use in combination with a wide range of pumps and pumping systems in which pump pulsating output is variable.

**[0009]** U.S. Pat. No. 5,639,219 to Conatser provides a paint sprayer that employs a dampener in the form of a T-shaped fitting having a volume dampening chamber with a trapped volume of air which dampens the acceleration/deceleration forces and acceleration spikes transmitted from the pump to the delivery fluid. Conatser, however, does not include CIP or a sensing mechanism for monitoring and adjusting the air-to-liquid ratio in the dampening chamber.

**[0010]** U.S. Pat. No. 2,764,103 to Mercier discloses a pulsation dampener for a pump mechanism that reduces the effects of pumping pulsation whereby a deformable rubber bladder encased in a pressure accumulator to suppress pump pressure surges. The accumulator includes a valve for pressurizing a gas inside the bladder to suppress the pump spikes resulting from the operation of the pump piston. Mercier, however, lacks CIP or probes or sensing devices for accommodating the ratio between the air and liquid.

**[0011]** Heretofore, none of the aforementioned prior art systems are equipped for high pressure and high-speed fluid metering and pumping (i.e., pressure ranges of **400** pounds

psi or greater and pumping cycles in the range of about 20-200 cycles per minute and preferably 60-160 cycles per minute) in delivering precise measured quantities of fluids at accurate flow rates. Many prior art systems are also not adaptable for use in sanitary filling operations since they lack a pump pulsation dampening assembly that also meets the cleaning-in-place standards required by the FDA. The prior art also fails to provide an attachment for accommodating a wide range of pumps and pumping systems or a method of dampening pulsations resulting from the operation of various pumps. The prior art also lacks a device that monitors and adjusts the air-to-liquid ratio inside a pump pulsation dampening attachment in response to the duration and intensity of the pulsating fluid flow.

#### SUMMARY OF THE INVENTION

[0012] Accordingly, it is an object of the invention to provide a pump delivery system that is adaptable for a variety of sanitary filling operations.

[0013] It is another object of the invention to provide such a pump delivery system that is adaptable for high-pressure and high-speed capacity pumping operations.

[0014] It is an additional object of the invention to provide such a pump delivery system adapted for use with a variety of pump mechanisms.

[0015] It is a further object of the invention to provide such a pump delivery system that facilitates the efficient delivery of fluids by providing a pump pulsation dampening attachment that dampens the pulsating flow output generated by the pump mechanism.

[0016] It is yet another object of the invention to provide such a pump delivery system adaptable to monitor and adjust the air-to-liquid ratio inside a pump pulsation dampening attachment in response to the duration and intensity of the pulsating fluid flow.

[0017] It is still another object the invention to provide such a pump delivery system that facilitates effective cleaning-in-place (CIP).

[0018] In accordance with these objects and the principles of the invention, provided herein is a pump delivery system including a pump mechanism for delivering a liquid under pressure and which generates a pulsating output during operation, and a pump pulsation dampening assembly for substantially reducing the pulsating output of the pump mechanism. In accordance with this aspect of the invention, the pump pulsation dampening assembly includes a pressurized vessel having an interior surface defining a chamber for receiving the liquid from the pump mechanism, the chamber also containing a pocket of pressurized air therein for absorbing the pulsating output generated by the pump mechanism; a sensing mechanism for monitoring the air-to-liquid ratio inside the chamber, the sensing mechanism being adaptable for producing an output signal in response thereto; and an adjustment mechanism in communication with the sensing mechanism and adapted to receive the output signal from the sensing mechanism and to provide an adjustment to the air-to-liquid ratio inside the chamber to a desired level in response thereto.

[0019] The invention is also directed to a pump delivery system including a pump mechanism for delivering a liquid

under pressure, the pump mechanism also generating a pulsating output during operation, and a pump pulsation dampening assembly for dampening the pulsating output of the pump mechanism. In accordance with this aspect of the invention, the pump pulsation dampening assembly includes a pressurized vessel having an interior surface defining a chamber for receiving the liquid, the chamber also containing a pocket of pressurized air therein for absorbing the pulsating output, the chamber being sized to correspond to the duration and intensity level of the pulsating output.

[0020] The invention is further directed to a pump pulsation dampening attachment including a pressurized vessel having an interior surface defining a chamber for receiving a liquid, the chamber containing a pocket of air therein for absorbing pulsating fluid flow; and a sensing mechanism for monitoring and adjusting the air-to-liquid ratio inside the chamber in response to the duration and intensity of the pulsating fluid flow.

[0021] The invention is also directed to a pump pulsation dampening attachment comprising a pressurized vessel having an inlet end for receiving a liquid, an outlet end for dispensing the liquid, an interior surface defining a chamber for containing the liquid, the chamber also containing a pocket of air therein for absorbing pulsating flow of the liquid, and a control end for controlling the air-to-liquid ratio inside the chamber in response to the duration and intensity of the pulsating fluid flow.

[0022] The invention is even further directed to a pump delivery system adapted for use in a sanitary filling operation, the pump delivery system including a pump mechanism that generates a pulsating output when delivering a liquid under pressure to a filling machine, the pump mechanism having an inlet port for receiving the liquid and an outlet port in communication with the filling machine for transporting the liquid thereto; and a pump pulsation dampening assembly for dampening the pulsating output of the pump mechanism, the pump pulsation dampening assembly disposed in communication with the outlet port and in communication with the filling machine. In accordance with this aspect of the invention, the pump pulsation dampening assembly includes a pressurized vessel having an inlet port for receiving the liquid from the outlet of the pump mechanism, an outlet port for permitting a flow of the liquid into the filling machine, and an interior surface defining a chamber for containing and receiving a volume of the liquid from the pump mechanism, the chamber also containing a pocket of pressurized air therein for absorbing the pulsating output generated by the pump mechanism, a sensing mechanism for monitoring the air-to-liquid ratio inside the chamber, the sensing mechanism being adaptable for producing an output signal in response thereto, an adjustment mechanism in communication with the chamber for providing an adjustment to the air-to-liquid ratio inside the chamber to a desired level in response to the output signal produced by the sensing mechanism, a sanitary cleaning mechanism for cleaning-in-place the interior surface of the pressurized vessel, and a supplemental dampener and pulse rate indicator in communication with the pressurized vessel for absorbing at least a portion of the pulsating output generated by the pump mechanism and also serving as a visual indicator of the pulsation rate of the pump mechanism.

[0023] The invention is also directed to a method of dampening pulsations associated with a pump mechanism

which generates a pulsating output during operation, the method including the steps of utilizing a pressurized vessel having an interior surface defining a chamber for receiving a certain volume of the liquid from the pump mechanism, the chamber containing a pocket of pressurized air therein; sizing the volumetric capacity of the chamber in response to the duration and intensity level of the pulsating output; employing a supplemental dampener and pulse rate indicator in communication with the pressurized vessel; absorbing the pulsating output using the pocket of pressurized air; supplementing the absorbing step by absorbing at least a portion of the pulsating output using the supplemental dampener and pulse rate indicator; and observing the pulse rate of the pump mechanism using the supplemental dampener and pulse rate indicator.

[0024] Accordingly, the pump delivery system in accordance with the invention is advantageous in being adaptable to quickly and efficiently deliver fluids by minimizing flow pulsations caused by the pulsing output of the pump mechanism. The pump delivery system is also advantageous in reducing manufacturing costs and increasing production. The pump delivery system is further advantageous in providing a system that meets FDA standards in facilitating the cleaning-in-place of the interior surface of the pressurized vessel.

[0025] Moreover, the pump delivery system in accordance with the invention may be used not only for sanitary operations but all high-speed capacity pumping operations, particularly where constant pressure is desired. In this regard, the pump delivery system is adaptable for various pump mechanisms, particularly those that are adapted for high-speed operations that require constant pressure.

[0026] These and other objects, features and advantages of the invention will become more apparent from the following description when taken in conjunction with the detailed drawings that show, for purposes of illustration only, the preferred embodiments of the invention.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0027] The advantages of the invention will become more apparent to those skilled in the art in conjunction with the detailed description of the preferred embodiments of the invention, in which:

[0028] FIG. 1 is a side elevational view partly in section of the novel pump delivery system adapted for use in a sanitary filling operation;

[0029] FIG. 2 is a side elevational view partly in section of the pump pulsation dampening attachment equipped with a sanitary cleaning mechanism for cleaning-in-place the interior surface of the pressurized vessel;

[0030] FIG. 3 is a side elevational view partly in section of the novel pump delivery system adaptable for a diaphragm pump;

[0031] FIG. 4 is a side elevational view partly in section of the pump pulsation dampening attachment equipped with a sanitary cleaning mechanism for cleaning-in-place the interior surface of the pressurized vessel;

[0032] FIG. 5 is a side elevational view partly in section of the novel pump delivery system adaptable for a centrifugal pump;

[0033] FIG. 6 is a side elevational view partly in section of the novel pump delivery system adapted for use in a sanitary filling operation in accordance with another embodiment of the invention, the system including a supplemental dampener and pulse rate indicator for absorbing at least a portion of the pulsating output generated by the pump mechanism;

[0034] FIG. 7 is a side elevational view partly in section of the pump pulsation dampening attachment in accordance with another embodiment of the invention, whereby the pump pulsation dampening assembly is equipped with a sanitary cleaning mechanism and a supplemental dampener and pulse rate indicator;

[0035] FIG. 8 is a side elevational view partly in section of the novel pump delivery system adaptable for a diaphragm pump;

[0036] FIG. 9 is a side elevational view partly in section of the pump pulsation dampening assembly in accordance with another embodiment of the invention, whereby the pump pulsation dampening attachment is equipped with a sanitary cleaning mechanism and a supplemental dampener and pulse rate indicator;

[0037] FIG. 10 is a side elevational view partly in section of the novel pump delivery system adaptable for a positive displacement pump;

[0038] FIG. 11 is a front elevational view partly in section illustrating the pump pulsation dampening attachment in accordance with another embodiment of the invention, whereby the pressure vessel is configured for pump mechanisms that produce low-intensity pulsations;

[0039] FIG. 12 is a front elevational view partly in section illustrating the pump pulsation dampening attachment shown in FIG. 9 having a pump delivery system adaptable for a diaphragm pump; and

[0040] FIG. 13 is a side elevational view partly in section of the novel pump delivery system that employs a double acting piston pump and a pressure vessel whereby the pressure vessel is configured for pump mechanisms that produce low-intensity pulsations.

#### DETAILED DESCRIPTION OF THE INVENTION

[0041] As shown in FIG. 1, in a first embodiment of the invention, a pump delivery system 10 adapted for use in a sanitary filling operation that includes a filling machine 140 whereby a viscous fluid or liquid (L) is delivered to a fluid manifold 150 in communication with a plurality of fill heads 160 which dispense the fluid to respective containers (not shown).

[0042] As shown in FIGS. 1, 6, 8 and 13, the pump delivery system 10 of the invention includes a pump mechanism 20 mechanically driven by a motor 30 for delivering the liquid (L) under pressure to the filling machine 140, the pump mechanism 20 generating a pulsating output during operation. As shown in FIGS. 1 and 11, the pump mechanism 10 may include a double acting piston head 21 driven by a drive shaft 22 having a pair of inlet ports 23, 24 for receiving the liquid (L) and a pair of outlet ports 40, 41 in communication with a pump pulsation dampening attachment or assembly 50 for transporting the liquid (L) thereto.

As illustrated in **FIG. 6**, each embodiment of the invention may be provided with a mass flow sensor **42**, preferably of any type known in the art.

[0043] As illustrated in **FIGS. 3, 5, 10** and **12**, the pump delivery system **10** is not limited to the pump mechanism embodied in **FIGS. 1, 6, 8** and **13**, and are adaptable for a wide-variety of pump mechanisms **20**, such as, but not limited to, diaphragm pumps, centrifugal pumps, and positive displacement pumps, etc. The pump delivery system **10** is also adaptable for pumps that are capable of achieving high-pressure rates, e.g., pressure ranges of 400 pounds psi or greater and pumping cycles in the range of about 20-200 cycles per minute and preferably 60-160 cycles per minute.

[0044] The pump pulsation dampening assembly **50** is provided for substantially dampening the pulsating flow output generated by the pump mechanism **20**, and is disposed in series with the sanitary pump mechanism **20** and the filling machine **140**. In particular, the pump pulsation dampening assembly **50** is disposed in the fluid flow path downstream of the pump mechanism **20** and upstream of the final dispensing destination, in this example, the filling machine **140**.

[0045] The pump pulsation dampening assembly **50** includes a generally cylindrical pressurized vessel **60** having a sealed inlet port **61** for receiving the liquid (L) from the outlets **40, 41** of the pump mechanism **20**, a sealed outlet port **62** for permitting a flow of the liquid (L) into the filling machine **140**, and a control end that includes pressure regulator **70**, over pressure relief valve **80**, sensing mechanism **90**, supplemental dampener/pulse rate indicator **100** and sanitary cleaning mechanism **110**. A control valve **64** is provided to permit the transfer of the liquid (L) into the fluid manifold **150** while prevented the back flow of the liquid into the vessel **60**. It is preferred that the vessel **60** and all components associated therewith is composed of self-lubricating, abrasive-resistant, rust-resistant and hygienic materials. Most preferably, a material such as stainless steel is utilized to form the vessel **60**.

[0046] The vessel **60** also has an interior surface defining a chamber **63** for receiving a volume of liquid (L) from the pump mechanism **20**, the chamber **63** also having a volume of pressurized air, i.e., an air pocket (A) therein for absorbing the pulsating fluid flow output generated by the pump mechanism **20**, and thereby maintain constant fluid flow during delivery operations. Accordingly, the air pocket (A) inside the chamber **63** behaves as a cushion in absorbing the pulsating flow. Because the intensity level of the pulsations vary between different pump mechanisms, the size of the vessel **60**, specifically, the volumetric capacity of the chamber **63**, should correspond to the type of pump mechanism **20** utilized in the pump delivery system **10**. For instance, because centrifugal pumps cause low intensity pulsations, the volumetric capacity of the chamber **63** should correspondingly be low since less dampening is required. On the other hand, reciprocating pumps generate high intensity pulsations, a chamber **63** having a large volumetric capacity should be used. Accordingly, the pump delivery system **10** of the invention accommodates for the wide-range of pulsation intensities associated with different pumps by providing vessels **60** with chambers **63** of varying volumetric capacities. For instance, the vessels **60** shown in **FIGS. 1-8** have chambers **63** of generally large volumetric capacities

while the vessels shown in **FIGS. 9-13** have chambers **63** of generally smaller volumetric capacities.

[0047] Moreover, the desired liquid-to-air ratio provided in the chamber **63** may change depending upon the requirements of the delivery operations, which may take into account, the different types of pump mechanisms **20** utilized, changes in the liquid viscosity and liquid density, and other factors such as temperature, humidity, etc.

[0048] The vessel **60** is sealingly provided with a sensing mechanism **90** for monitoring the air-to-liquid ratio and/or pressure inside the chamber **63**, said sensing mechanism **60** being adaptable to produce or otherwise transmit an electronic output signal in response thereto. The sensing mechanism **90** includes a main body **92** with an elongated tube or probe **91** fixedly extended therefrom. During a delivery operation, if the level of the liquid (L) reaches a height so as to contact the distal end of the probe **91**, thereby indicating an impermissible air-to-liquid ratio inside the chamber **63**, the sensing mechanism **90** transmits the output signal to the adjustment mechanism **93**. Alternatively, the probe **91** may also be equipped with a transducer to enable sensing of the pressure level inside the chamber **63**, and in turn transmit a signal to the adjustment mechanism **93** in response to the sensing of an undesirable pressure level. While the drawing figures illustrate the use of a single probe **91**, it is apparent to those skilled in the art that the sensing mechanism **90** may employ a plurality of probes **91** to sense the fluid level, the air-to-liquid ratio and/or the pressure inside of the chamber **63**. Moreover, the probe **91** may alternatively be adaptable to reciprocate telescopically along its vertical axis to extend further into the chamber **63**.

[0049] As illustrated in **FIGS. 2, 4, 7**, and **9-13**, the adjustment mechanism **93** is in sealing communication with the chamber **63** and includes an air source (not shown) and a receiver configured to receive the output signal from the sensing mechanism **90**. In response to an indication of an increase in the fluid level, or an otherwise reduction in the air-to-liquid ratio, the adjustment mechanism **93** automatically adjusts the air pressure in the chamber **63** by providing a volumetric increase of air inside therein to a desirable level. To minimize parts of the overall assembly, the sensing mechanism **90** and the adjustment mechanism **93** may be combined to form a single unit that accomplishes the tasks of sensing the fluid, air-to-liquid ratio and/or air pressure in the chamber **63** and making the necessary adjustments in response thereto.

[0050] The pressure regulator **70** and over-pressure relief valve **80** are sealingly disposed in communication with the chamber **63**. The pressure regulator **70** may be of any type known in the art that is configured to perform within the range of pressures for which is required, and may also have a sanitary design compatible with pharmaceutical or food applications. The over pressure relief valve **80** may be of any type known in the art that is configured to discharge air when the pressure exceeds a desired or permissible level and may also have a sanitary design compatible with pharmaceutical or food applications.

[0051] As illustrated in **FIGS. 2, 4, 7, 9, 11** and **13**, for those applications that require the sanitary filling of liquids (L) into containers, the vessel **60** preferably includes a sanitary cleaning mechanism **110** for cleaning-in-place (CIP) the interior surface of the pressurized vessel **60**. The

sanitary cleaning mechanism **110** includes a conduit **120** having an inlet port for receiving a volume of sanitized fluid from a sanitized fluid source (not shown) and an outlet port disposed inside the chamber **63** for dispensing a sufficient volume of sanitized fluid to facilitate the CIP operation. The outlet port may be provided with a generally circular nozzle head **130** having a plurality of apertures for spraying the sanitized fluid into the chamber **63** and on the interior surface of the vessel **60**. The nozzle head **130** may have any geometric shape that permits the effective spraying of sanitizing fluid during a CIP operation. In this regard, the conduit **120** and nozzle head **130** should preferably have sanitary designs that are compatible with pharmaceutical or food applications.

[0052] As illustrated in FIGS. 4-7, in order to provide an even effective manner of dampening pump output pulsations during a delivery operation, each embodiment of the pump delivery system **10** may further include a supplemental dampener/pulse rate indicator **100** that is placed in communication with the pressurized vessel and which absorbs at least a portion of the pulsating output generated by the pump mechanism **20**. The supplemental dampener/pulse rate indicator **100** includes an expandable vessel **101** having an interior chamber in direct fluid communication with the vessel chamber **63** to thereby expand and contract (see hatched lines) in response to the pulsating action of the pump mechanism **20**. As an added safety feature to contain the possible event of the expandable vessel **101** going beyond its elastic capacity, the expandable vessel **101** is sealingly enclosed in an expandable container **102**. It is especially preferred that the container **102** is composed of a clear translucent material to permit the expandable vessel **101** to be seen by the eye. Such a feature is advantageous in permitting the supplemental dampener/pulse rate indicator **100** to also serve as a visual indicator of the pulse rate of the output from the pump mechanism **20**. It is preferable that the expandable vessel **101** is composed of a deformable material having mechanical memory that allows the expandable vessel **100** to maintain its form even in occurrences of large pulsations. It is even more preferable that the deformable material comprises rubber.

[0053] As illustrated in FIG. 9, the supplemental dampener/pulse rate indicator **100** may further include a pair of expandable vessels including an inner vessel **101** in direct communication with the chamber **63** and an outer vessel **103** that surrounds the inner vessel **101** to simultaneously expand and contract in relation to the pulsation output from the pump mechanism **20**. It is preferable that each expandable vessel **101**, **103** is composed of the same deformable material having mechanical memory. It is even more preferable that the deformable material comprises rubber. It is even more preferred that the rubber used for the inner vessel **101** is of a dark color while the rubber used for the outer vessel **103** is of a clear, translucent type to permit an enhanced visualization of the pulsing action.

[0054] The pump pulsation dampening assembly **50** operates by absorbing a volume of the liquid (L) during the discharge cycle of the pump **20**, while on the suction cycle of the pump cycle, the air inside the dampening mechanism **100** is forced, resulting in essentially smooth flow, thereby enabling the liquid (L) to continue moving rather than accelerating, decelerating, and stopping.

[0055] Accordingly, the invention is advantageous in providing a pressure delivery system adapted to automatically reduce, minimize, suppress or otherwise dampen undesirable pulsating outputs from the delivery pump, which results in consistent flow rates during fluid delivery, which has the added benefit of reducing production costs and increasing manufacturing output.

[0056] The invention is also advantageous in providing such a pump delivery system that is adaptable for high-speed capacity pumping operations where constant pressure is desired. The invention is even further advantageous in providing such a pump delivery system that is adaptable for sanitary filling operations, especially those requiring CIP. The invention is still further advantageous by varying the volumetric capacity of the vessel chamber in response to the pulsation differences between pump mechanisms.

[0057] It is apparent that innumerable variations of the preferred embodiments described hereinbefore may be utilized. However, all such variations within the spirit and scope of the invention are deemed to be covered by the claims.

What is claimed is:

1. A pump delivery system comprising:

a pump mechanism for delivering a liquid under pressure and which generates a pulsating output during operation; and

a pump pulsation dampening assembly for substantially reducing said pulsating output of said pump mechanism, said pump pulsation dampening assembly including:

a pressurized vessel having an interior surface defining a chamber for receiving the liquid from said pump mechanism, said chamber also containing a pocket of pressurized air therein for absorbing said pulsating output generated by said pump mechanism;

a sensing mechanism for monitoring the air-to-liquid ratio inside the chamber, said sensing mechanism being adaptable for producing an output signal in response thereto; and

an adjustment mechanism in communication with said sensing mechanism and adapted to receive said output signal from said sensing mechanism and to provide an adjustment to the air-to-liquid ratio inside said chamber to a desired level in response thereto.

2. The pump delivery system of claim 1, wherein said adjustment mechanism automatically provides an adjustment to said air-to-liquid ratio.

3. The pump delivery system of claim 1, wherein said pump mechanism comprises a diaphragm pump.

4. The pump delivery system of claim 1, wherein said pump mechanism comprises a positive displacement pump.

5. The pump delivery system of claim 1, wherein said pump mechanism comprises a centrifugal pump.

6. The pump delivery system of claim 1, wherein said pump mechanism comprises a piston pump.

7. The pump delivery system of claim 1, wherein said sensing mechanism comprises a main body and a probe extending therefrom and into said chamber, said probe being adaptable to monitor the air-to-liquid ratio inside said chamber.

8. The pump delivery system of claim 1, wherein said pump pulsation dampening assembly further comprises a pressure regulator in communication with said chamber.

9. The pump delivery system of claim 1, further comprising a sanitary cleaning mechanism for cleaning-in-place the interior surface of said pressurized vessel.

10. The pump delivery system of claim 9, wherein said sanitary cleaning mechanism comprises a conduit having an inlet port for receiving a volume of sanitized fluid from a sanitized fluid source and an outlet port disposed inside said chamber for dispensing a sanitized fluid therein to facilitate cleaning-in-place of said interior surface of said pressurized vessel.

11. The pump delivery system of claim 10, wherein said outlet port comprises a nozzle head having a plurality of apertures for discharging the sanitized fluid.

12. The pump delivery system of claim 1, wherein said pump pulsation dampening assembly further comprises an over-pressure relief valve in communication with said pressurized vessel for discharging air inside said chamber when the pressure inside said chamber exceeds a desired level.

13. A pump delivery system comprising a pump mechanism for delivering a liquid under pressure, said pump mechanism generating a pulsating output during operation, and a pump pulsation dampening assembly for dampening the pulsating output of said pump mechanism, said pump pulsation dampening assembly including a pressurized vessel having an interior surface defining a chamber for receiving the liquid, said chamber also containing a pocket of pressurized air therein for absorbing said pulsating output, said chamber being sized relative to the duration and intensity level of said pulsating output.

14. A pump pulsation dampening attachment comprising:

- (a) a pressurized vessel having an interior surface defining a chamber for receiving a liquid, said chamber containing a pocket of air therein for absorbing pulsating fluid flow; and
- (b) a sensing mechanism for monitoring and adjusting the air-to-liquid ratio inside said chamber in response to the duration and intensity of said pulsating fluid flow.

15. The pump pulsation dampening attachment of claim 14, further comprising a supplemental dampener and pulse rate monitor in communication with said chamber for absorbing at least a portion of said pulsating fluid flow and facilitating monitoring of the rate of pulsating fluid flow.

16. The pump pulsation dampening attachment of claim 14, further comprising a sanitary cleaning mechanism for cleaning-in-place the interior surface of said pressurized vessel.

17. The pump pulsation dampening attachment of claim 14, further comprising a pressure regulator in communication with said chamber.

18. A pump pulsation dampening attachment comprising a pressurized vessel having an inlet end for receiving a liquid, an outlet end for dispensing the liquid, an interior surface defining a chamber for containing the liquid, said chamber also containing a pocket of air therein for absorbing pulsating flow of the liquid, and a control end for controlling the air-to-liquid ratio inside said chamber in response to the duration and intensity of said pulsating fluid flow.

19. A pump delivery system adapted for use in a sanitary filling operation, said pump delivery system comprising:

- (a) a pump mechanism for delivering a liquid under pressure to a filling machine, said pump mechanism having an inlet port for receiving the liquid and an outlet port in communication with the filling machine for transporting the liquid thereto, said pump mechanism generating a pulsating output during operation; and

- (b) a pump pulsation dampening assembly for dampening the pulsating output of said pump mechanism, said pump pulsation dampening assembly disposed in communication with said outlet port and in communication with said filling machine, said pump pulsation dampening assembly including:

- (i) a pressurized vessel having an inlet port for receiving the liquid from said outlet of said pump mechanism, an outlet port for permitting a flow of the liquid into the filling machine, and an interior surface defining a chamber for containing and receiving a volume of the liquid from said pump mechanism, said chamber also containing a pocket of pressurized air therein for absorbing said pulsating output generated by said pump mechanism,

- (ii) a sensing mechanism for monitoring the air-to-liquid ratio inside the chamber, said sensing mechanism being adaptable for producing an output signal in response thereto,

- (iii) an adjustment mechanism in communication with said chamber for providing an adjustment to the air-to-liquid ratio inside said chamber to a desired level in response to said output signal produced by said sensing mechanism,

- (iv) a sanitary cleaning mechanism for cleaning-in-place the interior surface of said pressurized vessel, and

- (v) a supplemental dampener and pulse rate indicator in communication with said pressurized vessel for absorbing at least a portion of said pulsating output generated by said pump mechanism and also serving as a visual indicator of the pulsation rate of said pump mechanism.

20. The pump delivery system of claim 19, wherein said supplemental dampener and pulse rate indicator is enclosed in an expandable container.

21. The pump delivery system of claim 20, wherein said expandable container comprises a translucent material to permit the rate of pulsation to be observed manually without the aid of tools.

22. The pump delivery system of claim 19, wherein said supplemental dampener and pulse rate indicator comprises at least one expandable vessel having an interior chamber that expands and contracts in response to the pulsating action of said pump mechanism.

23. The pump delivery system of claim 22, wherein said expandable vessel comprises a deformable material having mechanical memory.

24. The pump delivery system of claim 23, wherein said deformable material comprises rubber.

25. A method of dampening pulsations associated with a pump mechanism which generates a pulsating output during operation, said method comprising the steps of:

- (a) utilizing a pressurized vessel having an interior surface defining a chamber for receiving a certain volume of the liquid from the pump mechanism, said chamber containing a pocket of pressurized air therein;
- (b) sizing the volumetric capacity of said chamber in response to the duration and intensity level of the pulsating output;
- (c) employing a supplemental dampener and pulse rate indicator in communication with said pressurized vessel;
- (d) absorbing the pulsating output using said pocket of pressurized air;
- (e) supplementing said absorbing step by absorbing at least a portion of said pulsating output using said supplemental dampener and pulse rate indicator; and
- (f) observing the pulse rate of said pump mechanism using said supplemental dampener and pulse rate indicator.

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