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Attorney Docket No. 98829

EXPLOSIVE WATER JET WITH PRECURSOR BUBBLE

[0001] This application claims the benefit of United States Provisional Patent Application Serial No. 60/963,207 filed on July 20, 2007 and entitled "Explosive Water Jet with Precursor Bubble" by the inventor, Thomas J. Gieseke.

STATEMENT OF GOVERNMENT INTEREST

[0002] The invention described herein may be manufactured and used by or for the Government of the United States of America for Governmental purposes without the payment of any royalties thereon or therefore.

CROSS REFERENCE TO OTHER PATENT APPLICATIONS

[0003] None.

BACKGROUND OF THE INVENTION

(1) Field of the Invention

[0004] The present invention relates to an assembly and a method of use for producing a high velocity water jet in a deep-water environment where depth pressure would typically inhibit the formation of a supercavitation bubble.

(2) Description of the Prior Art

[0005] High velocity jets are commonly used in industrial systems for cutting operations. For example: pressures of 380 Mpa (50,000 pounds per square inch), generated with specialized hydraulic pumps, are used to produce small diameter fluid jets with velocities approaching 800 meters per second. These systems are designed for precision and continuous cutting. As such, diameters of the fluid jets are typically very small (no greater than one millimeter).

[0006] Jet pulses of this size can only penetrate a short distance (typically one meter) in the water. Power consumption for significantly larger jets becomes prohibitive if sustained operation is required.

[0007] The water jet system described in United States Patent No. 6,868,790 (Gieseke et al.) is designed to overcome the jet formation inhibiting effects of water as a surrounding medium. The system and method of use of the cited reference utilizes a supercavity formed by an impulsively-created jet as a jet front propagates through the medium. At a significant depth (greater than one hundred meters) and under a high ambient pressure at the depth, the cavitation bubble, that would otherwise form at the jet front, is suppressed. For use in deep water drilling applications, a need therefore exists for forming the cavitation bubble that overcomes the jet formation inhibiting effects of water as a surrounding medium.

SUMMARY OF THE INVENTION

[0008] Accordingly, it is a general purpose and primary object of the present invention to provide an assembly and method of use for drilling in deep water applications.

[0009] It is a further object of the present invention to provide an assembly and method of use for creating a gas bubble at the water jet discharge nozzle through which high velocity water is expelled as a cutting system that overcomes the jet formation inhibiting effects of water as a surrounding medium.

[0010] To attain the objects described above, the present invention features an assembly and method of use for producing a pulsed jet. The assembly generally comprises a tank, feed lines for water an oxidizer line, a fuel line, a spark generator, discharge lines and control valves.

[0011] In operation, the tank is purged using a gaseous oxidizer. Any residual combustion gas and liquid is forced out of the tank through discharge valves and a nozzle. The discharge valves are then closed and the tank is filled with oxidizer. The oxidizer control valve is then closed and water or other cutting fluid is injected into the tank, thereby compressing the oxidizer within the tank.

[0012] When the cutting fluid attains a desired level in the tank, the control valve is closed and fuel is injected into the compressed oxidizer trapped above the cutting fluid. A spark generator ignites the fuel/air mixture; thereby, raising the pressure in the tank. As the pressure rises in the tank, a low-pressure control valve closes at a prescribed level. Simultaneously, a gas vent line is opened, as is a high-pressure discharge valve. Combustion gas is then free to discharge into the water medium through the discharge nozzle, thereby, forming a gas bubble at the nozzle exit.

[0013] When the gas bubble reaches a desired size and the pressure in the tank drops below a desired level, the gas vent line is closed, and the high pressure discharge valve opens to allow expansion of the combination gas. The gas forces the cutting fluid through the discharge nozzle.

[0014] The discharged cutting fluid forms a cutting jet. The presence of the gas bubble allows the jet to retain coherence as the water jet traverses the space between the nozzle and a cutting surface. After the cutting fluid has been expended, the remaining gas discharges through the nozzle, completing the cutting cycle.

[0015] Generally, the proposed water jet assembly and method of use overcomes difficulties with traditionally-used steady cutting jets and the pulsed difficulties of the jet described in

U.S. Patent No. 6,868,790 (incorporated herein by reference) by venting combustion gases immediately prior to the water jet in order to eliminate water resistance.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] A more complete understanding of the invention and many of the attendant advantages thereto will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in conjunction with the accompanying drawings wherein like reference numerals and symbols designate identical or corresponding parts throughout the several views and wherein:

[0017] **FIG. 1** depicts a schematic view of a pulsed jet generating system according to the present invention with the system in a purging operation;

[0018] **FIG. 2** depicts a schematic view of the pulsed jet generating system with the system in an oxidizer filling operation;

[0019] **FIG. 3** depicts a schematic view of the pulsed jet generating system with the system in a cutting fluid filling operation;

[0020] **FIG. 4** depicts a schematic view of the pulsed jet generating system with the system in a fuel injection operation;

[0021] **FIG. 5** depicts a schematic view of the pulsed jet generating system with the system in an ignition operation;

[0022] **FIG. 6** depicts a schematic view of the pulsed jet generating system according with the system in a gas-venting operation;

[0023] **FIG. 7** depicts a schematic view of the pulsed jet generating system with the system in a cutting jet formation;

[0024] **FIG. 8** depicts a schematic view of the pulsed jet generating system with the system in a tank-venting operation; and

[0025] **FIG. 9** is a graph depicting tank pressures as a function of time and operating steps.

DETAILED DESCRIPTION OF THE INVENTION

[0026] **FIG. 1** through **FIG. 8** illustrate the operation of the water jet system of the present invention. The system consists of a tank **10**, a water feed line **12**, an oxidizer line **14**, a fuel line **16**, a spark generator **18**, a gas vent **20**, a discharge line **22** and control valves **30, 32, 34, 36, 38, 40**.

[0027] In operation, the tank **10** is purged by the oxidizer line **14** using a gaseous oxidizer - such as air. As shown in **FIG. 1**, any residual combustion gas and liquid is forced out of the tank **10** in direction "A" through the discharge valves **38, 40**

and a nozzle **42** by using the oxidizer supplied by the oxidizer line **14** (See **Table 1** for valve sequencing).

[0028] The control valves **38, 40** are then closed and the tank **10** is filled with oxidizer (See **FIG. 2**). The control valve **30** is then closed and water by the water feed line **12** (or other cutting fluid) is supplied in direction "B" into the tank **10** by the opening of control valve **34,** thereby compressing the oxidizer within the tank (See **FIG. 3**).

[0029] When the cutting fluid attains a desired level **100** in the tank **10** (Direction "C"), the control valve **34** is closed and the control valve **32** in the fuel line **16** is opened and fuel is injected in Direction "D" to the compressed oxidizer trapped above the cutting fluid (See **FIG. 4**).

[0030] The spark generator **18** ignites the fuel/oxidizer mixture for an explosive ignition **120,** thereby, raising the pressure in the tank **10** (See **FIG. 5**). As the pressure rises in the tank **10,** the control valve **32** closes at a prescribed level (approximately 50 pounds per square inch over ambient pressure). Simultaneously, the control valve **36** of the gas vent line **20** is opened, as is the high-pressure discharge control valve **40.** Combustion gas is then free to discharge into the water medium through the discharge nozzle **42,** forming a gas bubble **140** at the nozzle exit (See **FIG. 6**).

[0031] When the gas bubble **140** reaches a desired size and the pressure in the tank **10** drops below a desired level, the control valve **36** closes, and the control valve **40** remains open to allow expansion of the combination gas (See **FIG. 7**). The expanding gas forces the cutting fluid **100** out of the tank **10** in Direction "E" through the discharge nozzle **42**.

[0032] The discharged cutting fluid **100** forms a cutting jet **160**. The presence of the gas bubble **140** allows the cutting jet **160** to retain coherence as the water of the cutting jet traverses a space between the nozzle **42** and a cutting surface. After the cutting fluid **100** has been expended, the remaining combustion gas discharges through the nozzle **42**, completing the cycle (See **FIG. 8**). To produce a pulsed cutting jet, the cycle is repeated in succession.

[0033] Pressures realized in the tank **10** over time during the cycle are shown in **FIG. 9**. The labeled phases of operation are: 1) purging; 2) oxidizer injection; 3) compression; 4) fuel injection; 5) combustion; 6) gas venting; 7) cutting jet formation; and 8) tank venting.

[0034] The valves used in the proposed system may be controlled via servo systems or through the use of pressure activation. **Table 1** matches the valve cycle phase and operation state ("x" denotes a closed state and "o" denotes an open state).

Table 1

Valve Sequencing

	Valve							
Phase	**Oxidizer in**	**Fuel in**	**Water/Cutting Fluid in**	**Gas vent**	**Upper Discharge**	**Lower Discharge**	**Start Pressure ***	**End Pressure ***
Purging	O	X	X	X	O	O	0	0
Oxidizer injection	O	X	X	X	X	X	0	1
Cutting fluid supply/Compression	X	X	O	X	X	X	1	10
Fuel injection	X	O	X	X	X	X	10	10`
Combustion	X	X	X	X	X	X	10	50
Gas venting	X	X	X	O	X	O	50	40
Cutting jet formation	X	X	X	X	O	O	40	10
Tank venting	X	X	X	X	O	O	10	0

- **Actuation pressures are dimensionless, relative, differential, and approximate.**

[0035] The foregoing description of the preferred embodiments of the invention has been presented for purposes of illustration and description only. It is not intended to be exhaustive nor to limit the invention to the precise form disclosed; and obviously many modifications and variations are possible in light of the above teaching. Such modifications and variations that may be apparent to a person skilled in the art are intended to be included within the scope of this invention as defined by the accompanying claims.

ABSTRACT

EXPLOSIVE WATER JET WITH PRECURSOR BUBBLE

A water jet assembly and method of use comprising a tank with cutting fluid, fuel and oxidizer lines, and a tank discharge lines. In operation, the tank is filled with oxidizer; the oxidizer line is closed and cutting fluid is supplied compressing the oxidizer. When the fluid reaches a level, the fluid line is closed and fuel is injected. A spark generator ignites the fuel/oxidizer mixture thereby raising the tank pressure. As the pressure rises, a low pressure valve simultaneously closes at a prescribed level. The vent line and a discharge to a nozzle are opened thereby, forming a gas bubble. When the bubble reaches a desired size and pressure drops below a level, the vent closes, allowing combustion expansion to force fluid through the nozzle to form a cutting jet. The bubble allows the jet to retain coherence between the nozzle and a cutting surface.

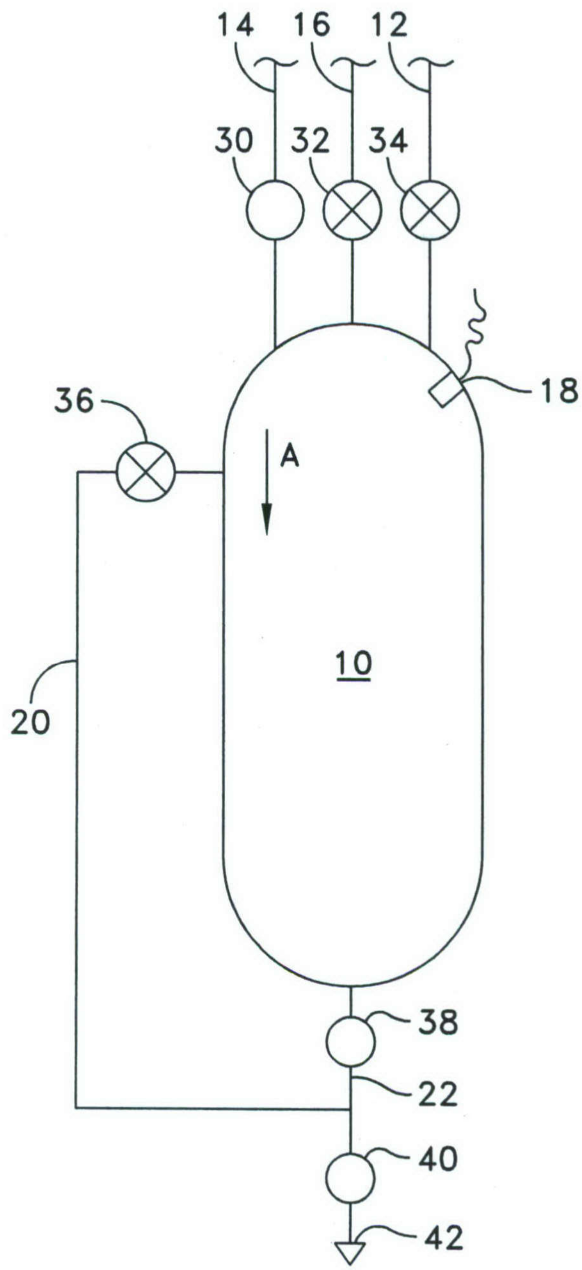

FIG. 1

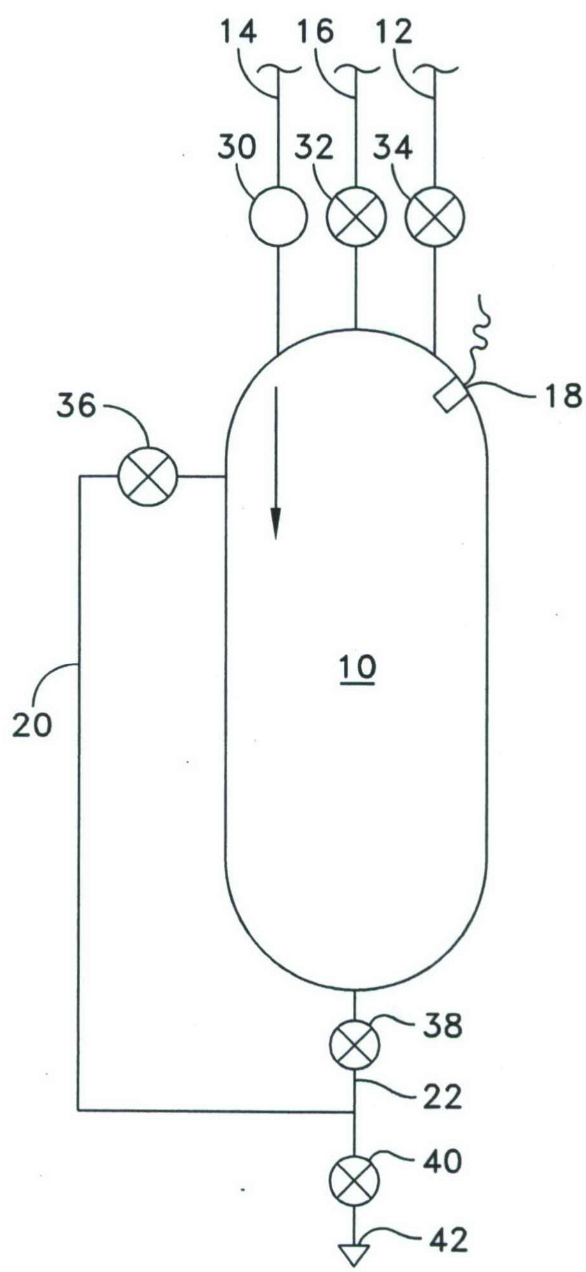

FIG. 2

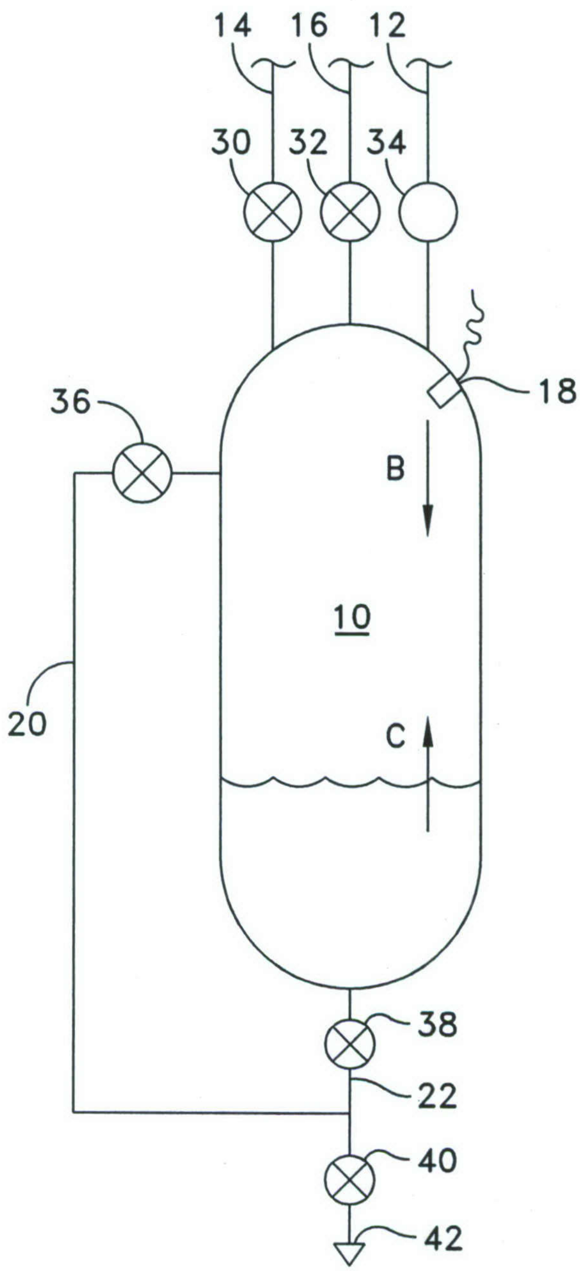

FIG. 3

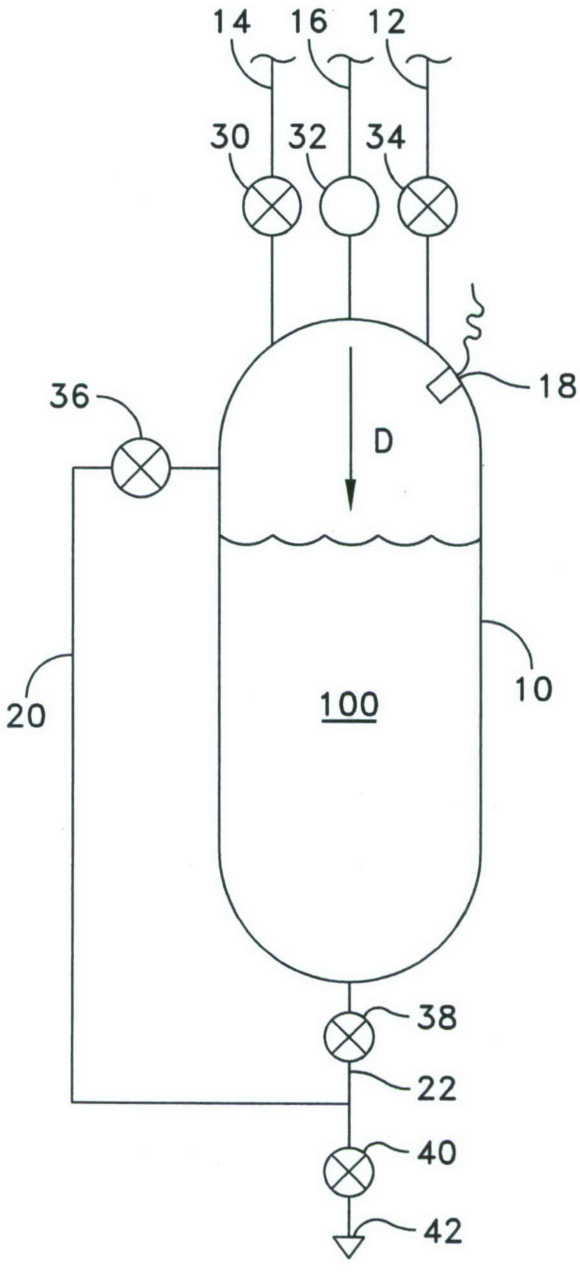

FIG. 4

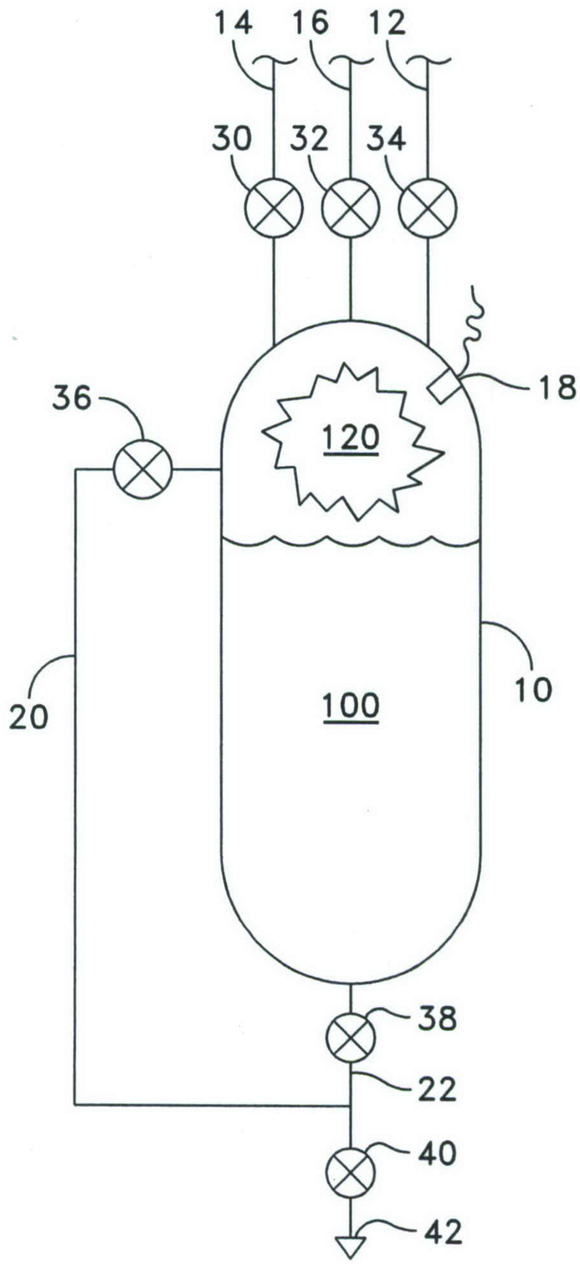

FIG. 5

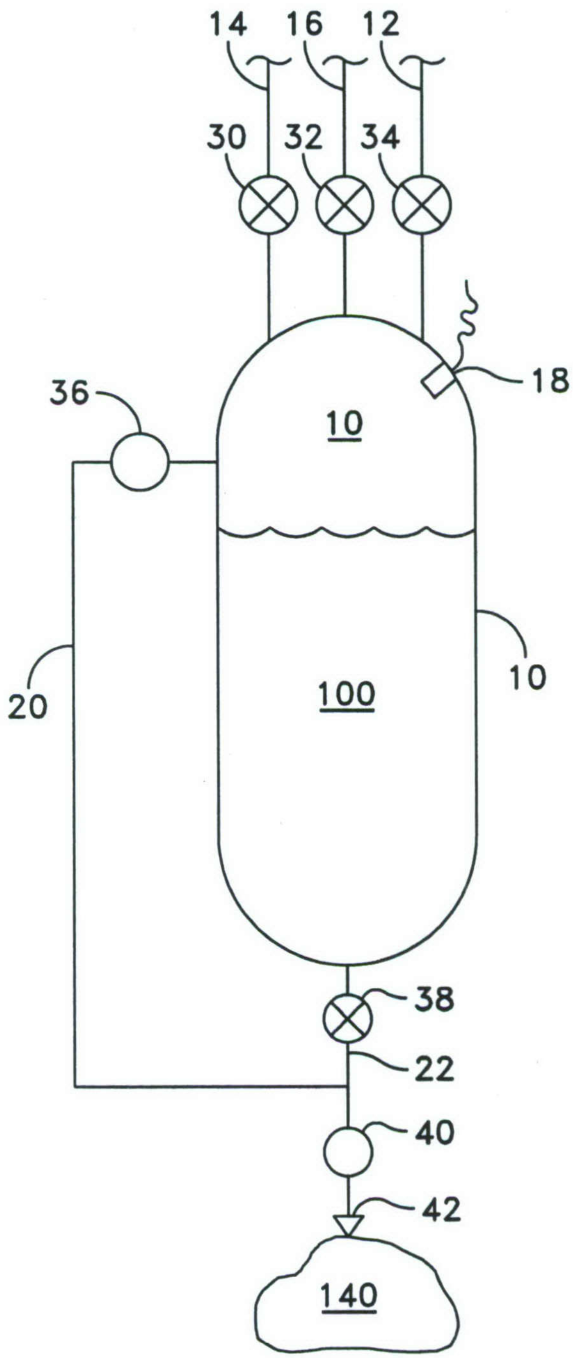

FIG. 6

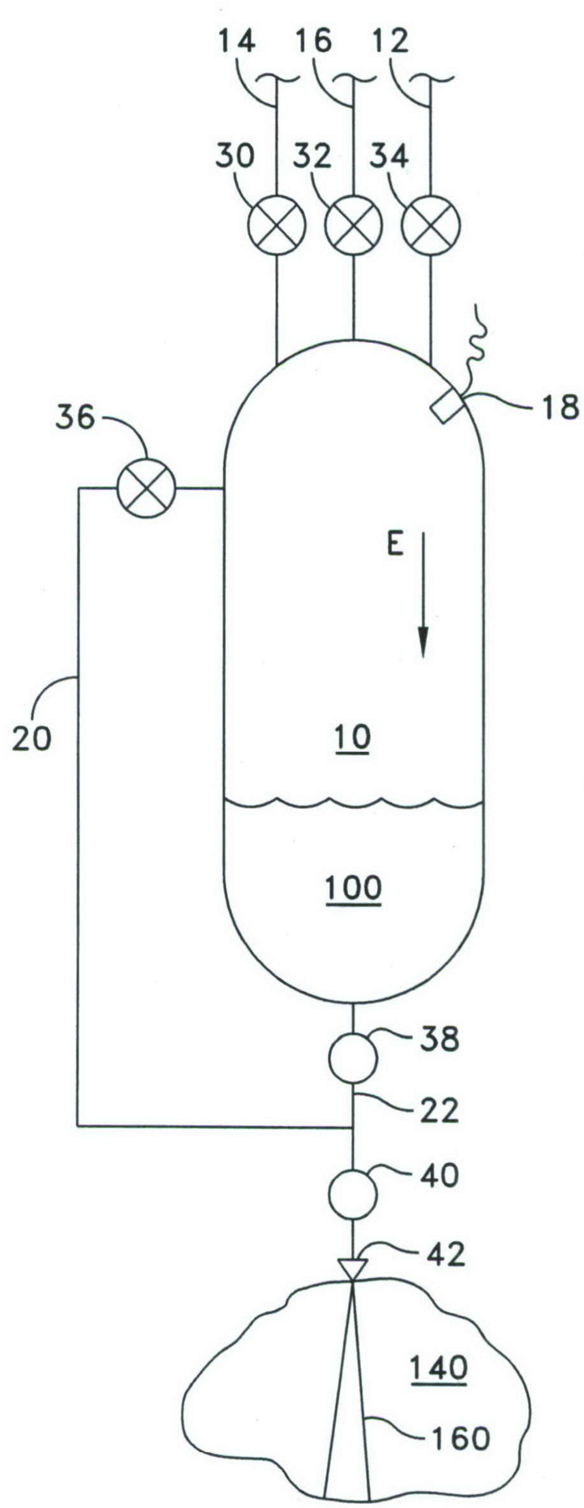

FIG. 7

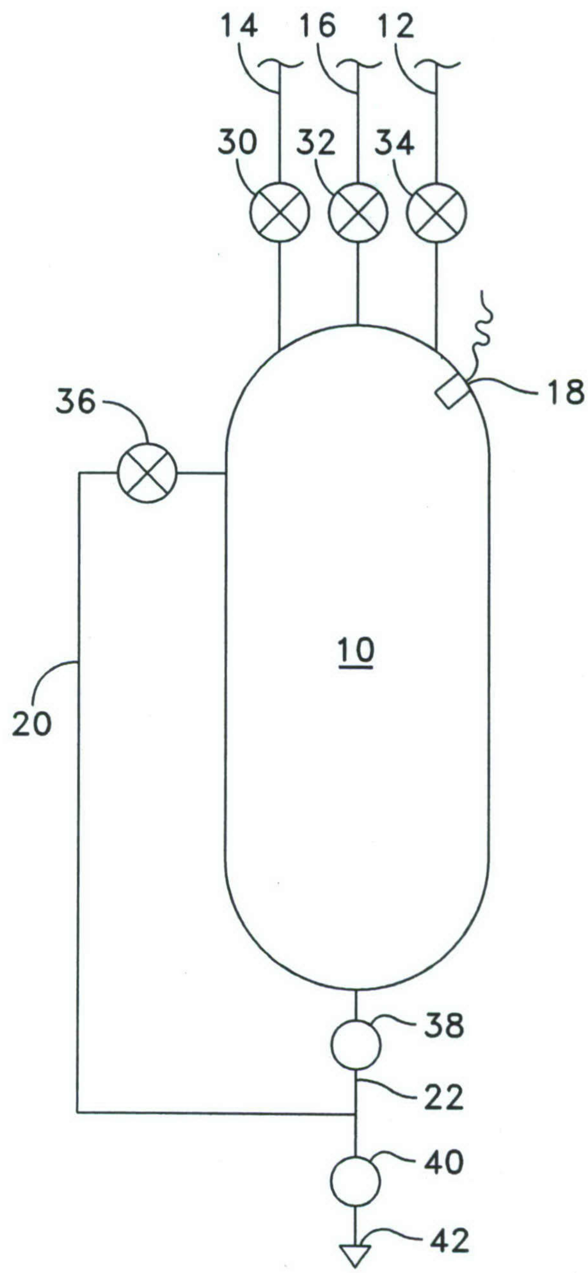

FIG. 8

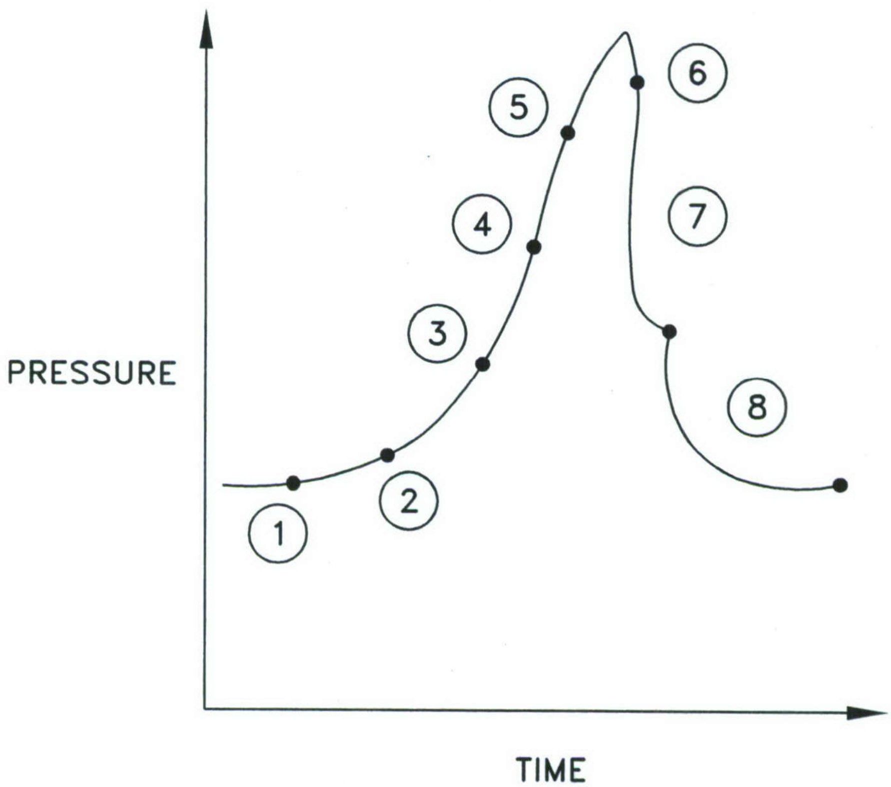

FIG. 9