(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 195 923 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
**22.03.2023 Bulletin 2023/12**

(21) Application number: **17150810.4**

(22) Date of filing: **10.01.2017**

(51) International Patent Classification (IPC):
***B01F 23/231*** *(2022.01)* ***B01F 23/234*** *(2022.01)*
***B01F 25/10*** *(2022.01)* ***B63G 8/34*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
**B63G 8/34; B01F 23/23121; B01F 23/2341; B01F 25/103**

(54) **SYSTEMS AND METHODS FOR GAS DISPOSAL**

SYSTEME UND VERFAHREN ZUR GASENTSORGUNG

SYSTÈME ET PROCÉDÉ DE MISE AU REBUT DE GAZ

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR**

(30) Priority: **15.01.2016 US 201614997287**

(43) Date of publication of application:
**26.07.2017 Bulletin 2017/30**

(73) Proprietor: **Hamilton Sundstrand Corporation**
**Charlotte, NC 28217 (US)**

(72) Inventors:
- **Colling, Jr, Arthur K.**
  **Monson, MA Massachusetts 01057 (US)**
- **Bishop, Benjamin E.**
  **Glastonbury, CT Connecticut 06073 (US)**
- **Thomas, Allison B.**
  **Hampden, MA Massachusetts 01036 (US)**

(74) Representative: **Dehns**
**St. Bride's House**
**10 Salisbury Square**
**London EC4Y 8JD (GB)**

(56) References cited:
**NL-A- 9 001 805**
**US-A- 3 425 669**
**US-A- 4 850 269**
**US-A- 5 910 248**

Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

EP 3 195 923 B1

## Description

### CROSS-REFERENCE TO RELATED APPLICATIONS

**[0001]** This application is a continuation-in-part of U.S. Patent Application No. 14/868,094 filed September 28, 2015.

### STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

**[0002]** This invention was made with government support under contract number NNX085-059 awarded by the United States Navy. The government has certain rights in the invention.

### BACKGROUND

#### 1. Field

**[0003]** The present disclosure relates to gas disposal, more specifically to dissolving gas into a liquid for underwater disposal.

#### 2. Description of Related Art

**[0004]** Operation of a vehicle underwater may generate gases that need to be discharged, e.g. disposed of, as an effluent. Generally, during this discharge, efforts are made to attempt to prevent bubbles from rising to the surface where they may be detected, or for bubbles to be released into the water column or form within the effluent discharge stream where they may also be detected.

**[0005]** One method of doing this is dissolving the gas into liquid. The term dissolving is at times referred to also as diffusing. Many different systems and methods, depending on application, are available for dissolving gases in liquids.

**[0006]** US 4850269 discloses means for carbonating water. NL 9001805 discloses methods for mixing liquids and gases by entraining gas.

**[0007]** Such conventional methods and systems have generally been considered satisfactory for their intended purpose. However, there is still a need in the art for improved gas discharge systems.

**[0008]** US4850269 discloses a discharge system as per the preamble of claim 1.

### SUMMARY

**[0009]** A discharge system includes a mixing vessel and a feedstock input in fluid communication with the mixing vessel as per the subject-matter of claim 1.

**[0010]** A solvent input is in fluid communication with the mixing vessel. A discharge output is in fluid communication with an outlet of the mixing vessel to discharge effluent. The mixing vessel includes a nozzle extending from a first side of the mixing vessel into a cavity defined by the mixing vessel. The solvent input is in fluid communication with the nozzle to direct a solvent toward a gas pocket generated by gas entering with feedstock through the feedstock input. The solvent input includes two lines. A first of the two lines defines a flow path to the mixing vessel through the nozzle and a second of the two lines defines a flow path to the mixing vessel through an inlet on a second side of the mixing vessel. The inlet on the second side of the mixing vessel is tangential to a wall of the mixing vessel to introduce swirl to fluid in the mixing vessel. The two lines can be downstream lines and the solvent input can include a single line upstream from the two lines and includes a flow split orifice between the single line and the two lines. The second of the two lines can be a diluent line.

**[0011]** A sparger can be operatively connected to an end of the feedstock input. The mixing vessel includes a nozzle extending from a first side of the mixing vessel into a cavity defined by the mixing vessel. The sparger can extend from the end of the feedstock input into the cavity to direct incoming feedstock evenly toward the nozzle and the first side of the mixing vessel. The discharge output can include a flow restrictor downstream from the outlet of the mixing vessel.

**[0012]** The cavity is defined between first and second sides of the mixing vessel. The mixing vessel can include packing material in the cavity for even flow of fluid throughout the mixing vessel. The packing material can be defined between the solvent input and the discharge output. The packing material can begin at a distance from the nozzle, measured along a longitudinal axis defined between the first and second sides of the mixing vessel, equal to one and one-half times a radius of the mixing vessel, e.g. wherein the mixing vessel includes a nozzle extending from a first side of the mixing vessel into a cavity defined by the mixing vessel. The packing material can extend through the mixing vessel along the longitudinal axis defined between the first and second sides of the mixing vessel a distance at least six times a radius of the mixing vessel. The mixing vessel can include a pair of perforated plates opposite from one another across the packing material. The sparger can extend from the end of the feedstock input into the packing material, e.g. wherein the sparger is operatively connected to an end of the feedstock input. The mixing vessel can have a larger diameter at a second end than at a first end.

**[0013]** In accordance with another aspect, a method as per the subject-matter of claim 13 for generating turbulence on a liquid surface within a discharge system as herein defined, to entrain gas into liquid includes supplying a mixing vessel with feedstock fluid and solvent fluid to generate a liquid mixture and a gas pocket in the mixing vessel. The method includes supplying an impinging solvent fluid through a nozzle extending from a first end of the mixing vessel to generate a roiling surface at an in-

terface between the gas pocket and the liquid mixture and permit uptake of gas from the gas pocket into the liquid mixture by entraining gas within the liquid mixture. The method includes supplying solvent through an inlet on a second side of the mixing vessel which is tangential to a wall of the mixing vessel to introduce swirl to fluid in the mixing vessel. In accordance with some embodiments, generating the roiling surface includes projecting the impinging solvent fluid out of the nozzle through the gas pocket and entraining gas from the gas pocket into the liquid mixture to a depth equal to or greater than one-half a radius of the mixing vessel. Entraining gas within the liquid mixture can include entraining a gas volume ranging from 2 to 20 times a liquid volume of the impinging solvent fluid.

**[0014]** These and other features of the systems and methods of the subject disclosure will become more readily apparent to those skilled in the art from the following detailed description taken in conjunction with the drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0015]** So that those skilled in the art to which the subject disclosure appertains will readily understand how to make and use the devices and methods of the subject disclosure without undue experimentation, embodiments thereof will be described in detail herein below with reference to certain figures, wherein:

Fig. 1 is a schematic depiction of an embodiment of a discharge system constructed in accordance with the present disclosure, showing the mixing vessel having a feedstock input and a solvent input;

Fig. 2 is a schematic depiction of a cross section of the discharge system of Fig. 1, with the packing material removed to show the lower perforated end plate;

Fig. 3 is a schematic depiction of a cross section of the discharge system of Fig. 1, with the packing material removed to show the sparger; and

Fig. 4 is a flow chart schematically depicting a method for generating turbulence on a liquid surface within a discharge system to entrain gas into liquid.

## DETAILED DESCRIPTION

**[0016]** Reference will now be made to the drawings wherein like reference numerals identify similar structural features or aspects of the subject disclosure. For purposes of explanation and illustration, and not limitation, an illustrative view of an embodiment of a discharge system in accordance with the disclosure is shown in Fig. 1 and is designated generally by reference character 100. Other embodiments and/or aspects of this disclosure are shown in Figures 2-4. The systems and methods described herein can be used to mix one or more soluble gas or gas and liquid feedstocks with a solvent, for example, saltwater, and discharge the solution with a known gas solubility saturation level such that the saturation level of gas in the liquid is well below that of typical bubble formation when released. This minimizes potential bubble formation from turbulent conditions or thermal hotspots after release.

**[0017]** As shown in Fig. 1, a discharge system 100 includes a mixing vessel 102 and a feedstock input 104 defining a feedstock flow path 108 in fluid communication with mixing vessel 102. It is contemplated that the feedstock through feedstock flow path 108 can be in the form of a gas or gas-fluid mixture and feedstock input 104 can draw from multiple feedstock sources. A longitudinal axis A is defined between first and second sides 117 and 119, respectively. A solvent input 106 is in fluid communication with mixing vessel 102. Feedstock dissolves within the solvent thereby generating an effluent discharge solution having a known gas solubility saturation. A discharge output 110 is in fluid communication with an outlet 112 of the mixing vessel 102 to discharge the effluent.

**[0018]** With continued reference to Fig. 1, solvent input 106 includes two lines. A first 107 of the two lines defines a flow path to mixing vessel 102 through a nozzle 118 and a second 107' of the two lines defines a flow path to mixing vessel 102 through an inlet 128 proximate to a second side 119 of mixing vessel 102, e.g. on a lower part 123 of mixing vessel 102 entering through a sidewall 121. Nozzle 118 extends from first side 117 of the mixing vessel 102 into a cavity 120 defined by mixing vessel 102. Solvent input 106 is in fluid communication with nozzle 118 to direct a solvent toward a gas pocket, indicated schematically with arcuate lines grouped together, generated by gas entering with the feedstock through feedstock input 104. Nozzle 118 provides a high velocity jet of solvent into feedstock gas and in bubbles being driven deep into the mixer fluid. It is contemplated that placement of nozzle 118 on first side 117, e.g. the top side, of mixing vessel 102 aids control of gas feed over the entire operating envelope, provides consistent uptake under pitch and roll as well as level cruise conditions, allows control of an interface 113 between the gas pocket and the liquid mixture, sustains continuous high gas uptake rate through improved kinetics, is easier to service, and provides even flow distribution across the surface area of the mixing vessel 102 making efficient use of the volume of mixing vessel 102.

**[0019]** With reference now to Figs. 1 and 2, in accordance with one embodiment, nozzle 118 can produce a highly kinetic cone shaped dispersion pattern of evenly distributed liquid droplet streams across the surface area at the interface between the gas pocket and the liquid mixture. The spray pattern of nozzle 118 is substantially symmetric, as schematically indicated in Fig. 1, to fully utilize the cross sectional area of mixing vessel 102. This, in turn, generates a substantially even roiling surface in order to maximize gas uptake from gas pocket into solvent present in the liquid mixture and that spraying from nozzle 118. A roiling surface, in accordance with some

embodiments, can be defined as a highly turbulent liquid/gas flow such that the impinging liquid, in this case the solvent incoming from nozzle 118, entrains gas from the gas pocket into the liquid to a depth of not less than one-half a radius R of mixing vessel 102 and preferably two times radius R. Nozzle 118 is positioned so that a tip 115 of nozzle 118 projects approximately 1.25-2.54 cm (0.5-1 inch) below the top of a cover 127 of mixing vessel 102 to improve initiation of a gas pocket and maintenance of the roiling surface during a given discharge of feedstock event.

**[0020]** With continued reference to Figs. 1 and 2, lines 107 and 107' are downstream lines. Solvent input 106 includes a single line 114 upstream from two lines 107 and 107' and includes a flow split orifice 116 between single line 114 and two lines 107 and 107'. Inlet 128 on second side 119 of mixing vessel 102 is tangential to sidewall 121 of mixing vessel 102 to introduce swirl to fluid in the mixing vessel 102. With this substantially tangential entrance, flow swirl occurs in the bottom of mixing vessel 102, as oriented in Fig. 2, providing both dilution of solvent flow from nozzle 118 and separation of possible bubbles within lower part 123 of mixing vessel 102. Lower part 123 is defined between second side 119 of mixing vessel 102 and a bottom perforated plate 136b, described below. These bubbles then flow radially inward toward longitudinal axis A of mixing vessel 102 and may float up through perforated plates 136b and 136a toward first side 117 of mixing vessel 102. A packing material 134, described in more detail below, is above inlet 128, as originated in Fig. 1, and reduces and/or eliminates the swirl from inlet 128, resulting in more even distribution as the bubbles rise to the top.

**[0021]** As shown in Figs. 1 and 3, a sparger 130 is operatively connected to an end of feedstock flow path 108 that is part of feedstock input 104. Sparger 130 extends from the end of the feedstock flow path 108 into cavity 120 to direct incoming feedstock evenly toward nozzle 118 and first side 117 of mixing vessel 102. Sparger 130 generates gas bubbles within mixing vessel 102 when feedstock is being fed into mixing vessel 102. In accordance with the embodiment shown in Fig. 3, sparger 130 is cross-shaped with holes 131 oriented upward toward first side 117 to create an even distribution of gas bubbles across mixing vessel 102 to counter downward flow, e.g. toward second side 119, of liquid solvent from nozzle 118. It is contemplated that a variety of sparger configurations and shapes can be used, for example, a spiral shape, an "X" shape, or any other suitable shape that provides even distribution over the span from front to back and side to side within mixing vessel 102.

**[0022]** Sparger 130 is placed near the bottom of mixing vessel 102, but within the zone of packing material 134, described below, so that additional uptake occurs in packing material 134, and small bubbles are swept from packing material 134 surface rather than allowed to accumulate and cause an increase in downward flow velocity of the solvent from nozzle 118. Sparger 130 includes holes 131 facing first side 117 of mixing vessel 102. Size and number of holes 131 is selected to maximize gas uptake at both low and high pressure conditions, and eliminate the potential for bubbles getting sucked into the effluent outlet stream. For example, holes 131 can be approximately 0.1 cm (0.040 inches) in diameter and spaced evenly along a pair of tubes that make up the cross shape. The bubbles generated need to be bubbles small enough to not impede liquid flow, yet the hole size and number of holes needs to be sufficient to keep injection pressure drop across sparger 130 within acceptable parameters.

**[0023]** Those skilled in the art will readily appreciate that the number of holes 131 and size of holes 131 can be selected such that about 0.07 bar (1 psi) of delta pressure is generated at the maximum volumetric flow of gas, and less than 0.14 bar (2 psi) of pressure is generated at the maximum flow of liquid-gas, for the desired feedstocks. Higher pressure drops tend to create either larger bubbles, which can result in a flow field impeding downward solvent flow, or high velocity jets of liquid which may also disturb the downward flow field. It is important to keep the downward flow field slow and even to allow small bubbles to ascend into the gas pocket at the top of mixing vessel 102. These bubbles may evolve in the solvent or feedstock, or cleave from larger bubbles at the exit of sparger 130.

**[0024]** As shown in Fig. 1, discharge output 110 includes a flow restrictor 132 downstream from outlet 112 of mixing vessel 102. The solvent liquid entering either nozzle 118 or inlet 128 can include other dissolved gases, e.g. atmospheric gases. The partial pressure of these other contaminate gasses over the solvent liquid is initially zero. When additional gas, such as that found in the feedstock, is added through feedstock input 104, the addition can cause some of the contaminate gas to leave the solvent and combine with the feedstock gas. Atmospheric gases, such as nitrogen and oxygen, have low solubility kinetics, and once allowed to come out of the solvent, are slow to dissolve. Further, they tend to form very small bubbles of low buoyancy that tend to be easily entrained in the discharge flow through discharge output 110 instead of being re-dissolved in the solvent and then discharged through outlet 112.

**[0025]** With continued reference to Fig. 1, flow restrictor 132 increases the pressure of the solution in mixing vessel 102. The resulting increase in pressure in mixing vessel 102 reduces the potential for atmospheric gases, such as nitrogen and/or oxygen, or other solvent gas contaminants from coming out of the solvent in mixing vessel 102. In accordance with some embodiments, a minimum pressure at discharge is less than four times a solvent surface pressure at ambient temperature. Flow restrictor 132 is sized to generate a delta pressure equal to four times the solvent surface pressure at ambient temperature minus the minimum pressure at outlet 112. For example, if ocean water is the solvent and the ocean surface pressure is 1 bar (15 psia) at ambient surface conditions,

the minimum discharge pressure from the vehicle is less than 4.1 bar (60 psia)

**[0026]** With reference now to Figs. 1 and 2, mixing vessel 102 includes packing material 134 in cavity 120 for even flow of fluid throughout mixing vessel 102. Mixing vessel 102 includes perforated plates 136, an upper perforated plate 136a and a bottom perforated plate 136b, opposite from one another across packing material 134. Packing material 134 is defined between solvent input 106 and discharge output 110. Packing material 134 begins at a distance Di from tip 115 of nozzle 118 measured along longitudinal axis A of the mixing vessel 102. Di is equal to one and one-half times radius R of the mixing vessel 102. Packing material 134 extends through mixing vessel 102 along longitudinal axis A the mixing vessel 102 a distance $D_2$. $D_2$ is at least six times radius R of mixing vessel 102.

**[0027]** It is contemplated that packing material 134 can have an effective void volume of greater than 90%. Sparger 130 is located above the bottom of packing material 134, and a mixing zone, e.g. lower part 123, where solute diluent is added free of packing material, is located below packing material 134 prior to outlet 112. Those skilled in the art will readily appreciate that the average void space created by packing material 134 can be greater than the maximum sparger bubbles generated when feedstock gas is added, allowing the bubbles to percolate up through packing material 134 and squeeze through upper perforated plate 136a into the turbulent mixing zone, e.g. area between nozzle 118 and upper perforated plate 136a. Packing material 134 acts as a buffer a zone between outlet 112 and nozzle tip 115 to reduce or eliminate turbulence from turbulent mixing zone and balance flow across the cross sectional area of mixing vessel 102. Further, cross flow patterns are reduced, regions for bubbles to become trapped before they can flow deeper are created, and the flow velocity after mixing allows more thorough distribution of saturated solute, preventing pockets or slugs of overly saturated effluent from being discharged.

**[0028]** As shown in Figs. 1 and 2, perforated plates 136a and 136b are used at the top and bottom of the zone of packing material 134 to properly position packing material 134. Each plate 136a and 136b has holes 137 equaling about 25% of the total cross sectional area, allowing low velocity relative to the nozzle turbulence, but sufficient to create pressure drop above upper perforated plate 136a resulting in fairly even flow distribution through packing material 134. The diameter of holes 137 is sized such that the solvent flow velocity in the downward direction is less than the bubble rise rate from sparger 130 so that gas entering mixing vessel 102 from sparger 130 is prevented or resisted from being entrained through bottom perforated plate 136b.

**[0029]** It is also contemplated that, in accordance with some embodiments, holes 137 of plates 136a and 136b are greater than the size of sparger holes 131 by more than 30%, since some pressure drop is generated in sparger 130 when feedstock gas flows, and the resulting bubbles expand as they enter cavity 120 of mixing vessel 102. Those skilled in the art will readily appreciate that all materials can be chemically compatible with the solvent and all feedstock fluids. It is also contemplated that mixing vessel 102 has a larger diameter at a lower end, e.g. proximate to inlet 128, than at first side 117.

**[0030]** As shown in Fig. 4, a method 200 for generating turbulence on a liquid surface within a mixing vessel, e.g. mixing vessel 102, includes supplying the mixing vessel with feedstock fluid through a feedstock input, e.g. feedstock input 104, and solvent fluid, e.g. a diluent, through an inlet, e.g. inlet 128, to generate a liquid mixture and a gas pocket in the mixing vessel, as shown by box 202. Method 200 includes supplying an impinging solvent fluid through a high dispersal nozzle, e.g. nozzle 118, extending from a first end, e.g. first side 117, of the mixing vessel to generate a roiling surface at an interface between the gas pocket and the liquid mixture and permit uptake of gas from the gas pocket into the liquid mixture, as shown by box 204. Generating the roiling surface includes projecting the impinging solvent out of the nozzle through the gas pocket and entraining gas from the gas pocket into the liquid mixture to a depth equal to or greater than one-half a radius, e.g. radius R, of the mixing vessel, as shown by box 206. Entraining gas from the gas pocket into the liquid mixture includes entraining a gas volume ranging from two to twenty times a liquid volume of the impinging solvent fluid, as indicated by box 208. The entrained gas volume can be less or more than two to twenty times the volume of the impinging solvent fluid, and can vary over a wide pressure and temperature range, and a wide range of gases or solvents. For example, liquid stream velocities from the nozzle greater 15.24 m/s (50 ft/sec) can have a greater delta pressure to achieve a roiling surface for a variety of gas-fluid and/or gas mixtures.

**[0031]** Embodiments of the invention provide a high surface area ratio and mechanical agitation through the nozzle to improve both soluble gas saturation and high uptake kinetics. Gas uptake is achieved by feeding the liquid solvent through the nozzle while managing the liquid level in mixing vessel 102 at an optimal gas uptake point. The methods and systems of the present disclosure, as described above and shown in the drawings, provide for discharge systems having superior properties including the ability to maximize uptake rate for a gas into a liquid solvent to form an effluent discharge solution, while still reducing and/or preventing bubbles in the effluent discharge.

## Claims

**1.** A discharge system (100), comprising:

a mixing vessel (102);
a feedstock input (104) in fluid communication

with the mixing vessel (102);
a solvent input (106) in fluid communication with the mixing vessel (102); and
a discharge output (110) in fluid communication with an outlet of the mixing vessel (112) to discharge effluent,
wherein the mixing vessel (102) includes a nozzle (118) extending from a first side of the mixing vessel (102) into a cavity (120) defined by the mixing vessel, wherein the solvent input (106) is in fluid communication with the nozzle (118) to direct a solvent toward a gas pocket generated by gas entering with feedstock through the feedstock input (104),
said system **characterized in that**:

the solvent input (106) includes two lines, wherein a first (107) of the two lines defines a flow path to the mixing vessel (102) through the nozzle (118), and wherein a second (107') of the two lines defines a flow path to the mixing vessel (102) through an inlet (128) on a second side (119) of the mixing vessel (102), and
the inlet (128) on the second side (119) of the mixing vessel (102) is tangential to a wall of the mixing vessel (102) to introduce swirl to fluid in the mixing vessel (102).

**2.** The discharge system of claim 1 wherein the two lines (107, 107') are downstream lines, wherein the solvent input (106) includes a single line (114) upstream from the two lines (107, 107') and includes a flow split orifice (116) between the single line (114) and the two lines (107, 107').

**3.** The discharge system of any preceding claim, wherein the second (107') of the two lines is a diluent line.

**4.** The discharge system of any preceding claim, further comprising a sparger (130) operatively connected to an end of the feedstock input (104), preferably wherein the mixing vessel (102) includes a nozzle (118) extending from a first side (117) of the mixing vessel (102) into a cavity (120) defined by the mixing vessel (102), wherein the sparger (130) extends from the end of the feedstock input (104) into a cavity (120) defined by the mixing vessel (102) to direct incoming feedstock evenly toward the nozzle (118) and the first side (117) of the mixing vessel (102).

**5.** The discharge system of any preceding claim, wherein the discharge output (110) includes a flow restrictor (132) downstream from the outlet (112) of the mixing vessel (102).

**6.** The discharge system of any preceding claim, wherein the mixing vessel (102) defines a cavity (120) between first (117) and second sides (119) of the mixing vessel (102), wherein the mixing vessel (102) includes packing material (134) in the cavity (120) for even flow of fluid throughout the mixing vessel (102).

**7.** The discharge system of claim 6, wherein the packing material (134) is defined between the solvent input (106) and the discharge output (110).

**8.** The discharge system of claim 6 or claim 7, wherein the mixing vessel (102) includes a nozzle (118) extending from a first side (117) of the mixing vessel (102) into a cavity (120) defined by the mixing vessel (102), wherein the packing material (134) begins at a distance from the nozzle (118), measured along a longitudinal axis (A) defined between the first (117) and second (119) sides of the mixing vessel, equal to one and one-half times a radius (R) of the mixing vessel (102).

**9.** The discharge system of any of claims 6-8, wherein the packing material (134) extends through the mixing vessel (102) along a longitudinal axis (A) defined between the first (117) and second (119) sides of the mixing vessel (102) a distance at least six times a radius (R) of the mixing vessel (102).

**10.** The discharge system of any of claims 6-9, wherein the mixing vessel (102) includes a pair of perforated plates (136a, 136b) opposite from one another across the packing material (134).

**11.** The discharge system of any of claims 6-10, further comprising a sparger (130) operatively connected to an end of the feedstock input (104), wherein the sparger (130) extends from the end of the feedstock input (104) into the packing material (134).

**12.** The discharge system of any preceding claim, wherein the mixing vessel (102) has a larger diameter at a second end than at a first end.

**13.** A method for generating turbulence on a liquid surface within a discharge system according to any one of the preceding claims, to entrain gas into the liquid, comprising:

supplying a mixing vessel (102) with feedstock fluid and solvent fluid to generate a liquid mixture and a gas pocket in the mixing vessel (102);
supplying an impinging solvent fluid through a nozzle (118) extending from a first end (117) of the mixing vessel (102) to generate a roiling surface at an interface between the gas pocket and the liquid mixture; and
entraining gas within the liquid mixture to permit

uptake of gas from the gas pocket into the liquid mixture,
**characterized in that** said method comprises supplying solvent through an inlet (128) on a second side (119) of the mixing vessel (102) which is tangential to a wall of the mixing vessel (102) to introduce swirl to fluid in the mixing vessel (102).

**14.** The method of claim 13 wherein generating the roiling surface includes projecting the impinging solvent fluid out of the nozzle (118) through the gas pocket and entraining gas from the gas pocket into the liquid mixture to a depth equal to or greater than one-half a radius (R) of the mixing vessel (102).

**15.** The method of claim 13 or claim 14 wherein entraining gas within the liquid mixture includes entraining a gas volume ranging from to 2 to 20 times a liquid volume of the impinging solvent fluid.

**Patentansprüche**

**1.** Ableitungssystem (100), umfassend:

einen Mischbehälter (102);
einen Ausgangsmaterialeingang (104) in Fluidverbindung mit dem Mischbehälter (102);
einen Lösungsmitteleingang (106) in Fluidverbindung mit dem Mischbehälter (102); und
einen Ableitungsausgang (110) in Fluidverbindung mit einem Auslass des Mischbehälters (112), um Abgas abzuleiten,
wobei der Mischbehälter (102) eine Düse (118) beinhaltet, die sich von einer ersten Seite des Mischbehälters (102) in einen Hohlraum (120) erstreckt, der durch den Mischbehälter definiert ist, wobei der Lösungsmitteleingang (106) in Fluidverbindung mit der Düse (118) steht, um ein Lösungsmittel in Richtung einer Gastasche zu leiten, die durch Gas erzeugt wird, das mit Ausgangsmaterial durch den Ausgangsmaterialeingang (104) eintritt,
wobei das System **dadurch gekennzeichnet ist, dass**:

der Lösungsmitteleingang (106) zwei Leitungen beinhaltet, wobei eine erste (107) der zwei Leitungen einen Strömungsweg zu dem Mischbehälter (102) durch die Düse (118) definiert und wobei eine zweite (107') der zwei Leitungen einen Strömungsweg zu dem Mischbehälter (102) durch einen Einlass (128) auf einer zweiten Seite (119) des Mischbehälters (102) definiert, und
der Einlass (128) auf der zweiten Seite (119) des Mischbehälters (102) tangential zu einer Wand des Mischbehälters (102) ist, um eine Verwirbelung von Fluid in dem Mischbehälter (102) einzubringen.

**2.** Ableitungssystem nach Anspruch 1, wobei die zwei Leitungen (107, 107') stromabwärtige Leitungen sind, wobei der Lösungsmitteleingang (106) eine einzelne Leitung (114) stromaufwärts von den zwei Leitungen (107, 107') beinhaltet und eine Strömungsteilungsöffnung (116) zwischen der einzelnen Leitung (114) und den zwei Leitungen (107, 107') beinhaltet.

**3.** Ableitungssystem nach einem vorhergehenden Anspruch, wobei die zweite (107') der zwei Leitungen eine Verdünnungsmittelleitung ist.

**4.** Ableitungssystem nach einem vorhergehenden Anspruch, ferner umfassend eine Verteilereinrichtung (130), die mit einem Ende des Ausgangsmaterialeingangs (104) wirkverbunden ist, wobei bevorzugt der Mischbehälter (102) eine Düse (118) beinhaltet, die sich von einer ersten Seite (117) des Mischbehälters (102) in einen Hohlraum (120) erstreckt, der durch den Mischbehälter (102) definiert ist, wobei sich die Verteilereinrichtung (130) von dem Ende des Ausgangsmaterialeingangs (104) in einen Hohlraum (120) erstreckt, der durch den Mischbehälter (102) definiert ist, um eingehendes Ausgangsmaterial gleichmäßig in Richtung der Düse (118) und der ersten Seite (117) des Mischbehälters (102) zu leiten.

**5.** Ableitungssystem nach einem vorhergehenden Anspruch, wobei der Ableitungsausgang (110) einen Strömungsbegrenzer (132) stromabwärts von dem Auslass (112) des Mischbehälters (102) beinhaltet.

**6.** Ableitungssystem nach einem vorhergehenden Anspruch, wobei der Mischbehälter (102) einen Hohlraum (120) zwischen einer ersten (117) und einer zweiten Seite (119) des Mischbehälters (102) definiert, wobei der Mischbehälter (102) Packmaterial (134) in dem Hohlraum (120) für gleichmäßige Strömung von Fluid durch den Mischbehälter (102) beinhaltet.

**7.** Ableitungssystem nach Anspruch 6, wobei das Packmaterial (134) zwischen dem Lösungsmitteleingang (106) und dem Ableitungsausgang (110) definiert ist.

**8.** Ableitungssystem nach Anspruch 6 oder 7, wobei der Mischbehälter (102) eine Düse (118) beinhaltet, die sich von einer ersten Seite (117) des Mischbehälters (102) in einen Hohlraum (120) erstreckt, der durch den Mischbehälter (102) definiert ist, wobei das Packmaterial (134) in einem Abstand von der Düse (118), der entlang einer Längsachse (A) ge-

messen wird, die zwischen der ersten (117) und der zweiten (119) Seite des Mischbehälters definiert ist, gleich dem Eineinhalbfachen eines Radius (R) des Mischbehälters (102) beginnt.

**9.** Ableitungssystem nach einem der Ansprüche 6-8, wobei sich das Packmaterial (134) durch den Mischbehälter (102) entlang einer Längsachse (A), die zwischen der ersten (117) und der zweiten (119) Seite des Mischbehälters (102) definiert ist, um einen Abstand von zumindest dem Sechsfachen eines Radius (R) des Mischbehälters (102) erstreckt.

**10.** Ableitungssystem nach einem der Ansprüche 6-9, wobei der Mischbehälter (102) ein Paar perforierte Platten (136a, 136b) gegenüber voneinander über das Packmaterial (134) beinhaltet.

**11.** Ableitungssystem nach einem der Ansprüche 6-10, ferner umfassend eine Verteilereinrichtung (130), die mit einem Ende des Ausgangsmaterialeingangs (104) wirkverbunden ist, wobei sich die Verteilereinrichtung (130) von dem Ende des Ausgangsmaterialeingangs (104) in das Packmaterial (134) erstreckt.

**12.** Ableitungssystem nach einem vorhergehenden Anspruch, wobei der Mischbehälter (102) einen größeren Durchmesser an einem zweiten Ende als an einem ersten Ende aufweist.

**13.** Verfahren zum Erzeugen von Turbulenz auf einer Flüssigkeitsoberfläche innerhalb eines Ableitungssystems nach einem der vorhergehenden Ansprüche, um Gas in die Flüssigkeit mitzuführen, umfassend:

Zuführen von Ausgangsmaterialfluid und Lösungsmittelfluid zu einem Mischbehälter (102), um ein Flüssigkeitsgemisch und eine Gastasche in dem Mischbehälter (102) zu erzeugen;
Zuführen eines auftreffenden Lösungsmittelfluids durch eine Düse (118), die sich von einem ersten Ende (117) des Mischbehälters (102) erstreckt, um eine wallende Oberfläche an einer Grenzfläche zwischen der Gastasche und dem Flüssigkeitsgemisch zu erzeugen; und
Mitführen von Gas innerhalb des Flüssigkeitsgemischs, um eine Aufnahme von Gas aus der Gastasche in dem Flüssigkeitsgemisch zu ermöglichen,
**dadurch gekennzeichnet, dass** das Verfahren Zuführen von Lösungsmittel durch einen Einlass (128) auf einer zweiten Seite (119) des Mischbehälters (102) umfasst, die tangential zu einer Wand des Mischbehälters (102) ist, um eine Verwirbelung von Fluid in dem Mischbehälter (102) einzubringen.

**14.** Verfahren nach Anspruch 13, wobei das Erzeugen der wallenden Oberfläche Spritzen des auftreffenden Lösungsmittelfluids aus der Düse (118) durch die Gastasche und Mitführen von Gas aus der Gastasche in das Flüssigkeitsgemisch zu einer Tiefe gleich einer oder größer als eine Hälfte eines Radius (R) des Mischbehälters (102) beinhaltet.

**15.** Verfahren nach Anspruch 13 oder Anspruch 14, wobei das Mitführen von Gas innerhalb des Flüssigkeitsgemischs Mitführen eines Gasvolumens im Bereich des 2- bis 20-Fachen eines Flüssigkeitsvolumens des auftreffenden Lösungsmittelfluids beinhaltet.

**Revendications**

**1.** Système de décharge (100), comprenant :

un récipient de mélange (102)
une entrée de charge d'alimentation (104) en communication fluidique avec le récipient de mélange (102) ;
une entrée de solvant (106) en communication fluidique avec le récipient de mélange (102) ; et une sortie de décharge (110) en communication fluidique avec une sortie du récipient de mélange (112) pour déverser des effluents,
dans lequel le récipient de mélange (102) comporte une buse (118) s'étendant depuis un premier côté du récipient de mélange (102) dans une cavité (120) définie par le récipient de mélange, dans lequel l'entrée de solvant (106) est en communication fluidique avec la buse (118) pour diriger un solvant vers une poche de gaz générée par le gaz entrant avec la charge d'alimentation à travers l'entrée de charge d'alimentation (104),
ledit système étant **caractérisé en ce que** :

l'entrée de solvant (106) comporte deux conduites, dans lequel une première (107) des deux conduites définit un chemin d'écoulement vers le récipient de mélange (102) à travers la buse (118), et dans lequel une seconde (107') des deux conduites définit un chemin d'écoulement vers le récipient de mélange (102) à travers une entrée (128) sur un second côté (119) du récipient de mélange (102), et
l'entrée (128) sur le second côté (119) du récipient de mélange (102) est tangente à une paroi du récipient de mélange (102) pour introduire un tourbillon dans le fluide dans le récipient de mélange (102).

**2.** Système de décharge selon la revendication 1, dans

lequel les deux conduites (107, 107') sont des conduites en aval, dans lequel l'entrée de solvant (106) comporte une conduite unique (114) en amont des deux conduites (107, 107') et comporte un orifice de séparation d'écoulement (116) entre la conduite unique (114) et les deux conduites (107, 107').

**3.** Système de décharge selon une quelconque revendication précédente, dans lequel la seconde (107') des deux conduites est une conduite de diluant.

**4.** Système de décharge selon une quelconque revendication précédente, comprenant en outre un arroseur (130) connecté fonctionnellement à une extrémité de l'entrée de charge d'alimentation (104), de préférence dans lequel le récipient de mélange (102) comporte une buse (118) s'étendant depuis un premier côté (117) du récipient de mélange (102) dans une cavité (120) définie par le récipient de mélange (102), dans lequel l'arroseur (130) s'étend depuis l'extrémité de l'entrée de charge d'alimentation (104) dans une cavité (120) définie par le récipient de mélange (102) pour diriger uniformément la charge d'alimentation vers la buse (118) et le premier côté (117) du récipient de mélange (102).

**5.** Système de décharge selon une quelconque revendication précédente, dans lequel la sortie de décharge (110) comporte un limiteur d'écoulement (132) en aval de la sortie (112) du récipient de mélange (102).

**6.** Système de décharge selon une quelconque revendication précédente, dans lequel le récipient de mélange (102) définit une cavité (120) entre les premier (117) et second côtés (119) du récipient de mélange (102), dans lequel le récipient de mélange (102) comporte un matériau de garnissage (134) dans la cavité (120) pour un écoulement uniforme de fluide dans tout le récipient de mélange (102).

**7.** Système de décharge selon la revendication 6, dans lequel le matériau de garnissage (134) est défini entre l'entrée de solvant (106) et la sortie de décharge (110).

**8.** Système de décharge selon la revendication 6 ou la revendication 7, dans lequel le récipient de mélange (102) comporte une buse (118) s'étendant depuis un premier côté (117) du récipient de mélange (102) dans une cavité (120) définie par le récipient de mélange (102), dans lequel le matériau de garnissage (134) commence à une distance de la buse (118), mesurée le long d'un axe longitudinal (A) défini entre les premier (117) et second (119) côtés du récipient de mélange, égale à une et demi fois un rayon (R) du récipient de mélange (102).

**9.** Système de décharge selon l'une quelconque des revendications 6 à 8, dans lequel le matériau de garnissage (134) s'étend à travers le récipient de mélange (102) le long d'un axe longitudinal (A) défini entre les premier (117) et second (119) côtés du récipient de mélange (102) sur une distance d'au moins six fois un rayon (R) du récipient de mélange (102).

**10.** Système de décharge selon l'une quelconque des revendications 6 à 9, dans lequel le récipient de mélange (102) comporte une paire de plaques perforées (136a, 136b) opposées l'une à l'autre à travers le matériau de garnissage (134).

**11.** Système de décharge selon l'une quelconque des revendications 6 à 10, comprenant en outre un arroseur (130) connecté fonctionnellement à une extrémité de l'entrée de charge d'alimentation (104), dans lequel l'arroseur (130) s'étend depuis l'extrémité de l'entrée de charge d'alimentation (104) dans le matériau de garnissage (134).

**12.** Système de décharge selon une quelconque revendication précédente, dans lequel le récipient de mélange (102) a un diamètre plus grand au niveau d'une seconde extrémité qu'au niveau d'une première extrémité.

**13.** Procédé pour générer des turbulences sur une surface liquide à l'intérieur d'un système de décharge selon une quelconque revendication précédente, pour entraîner du gaz dans le liquide, comprenant :

la fourniture à un récipient de mélange (102) d'un fluide de charge d'alimentation et d'un fluide de solvant pour générer un mélange liquide et une poche de gaz dans le récipient de mélange (102) ;
la fourniture d'un fluide solvant incident à travers une buse (118) s'étendant depuis une première extrémité (117) du récipient de mélange (102) pour générer une surface de roulement au niveau d'une interface entre la poche de gaz et le mélange liquide ; et
l'entraînement de gaz à l'intérieur du mélange liquide pour permettre l'absorption de gaz de la poche de gaz dans le mélange liquide,
**caractérisé en ce que** ledit procédé comprend la fourniture de solvant à travers une entrée (128) sur un second côté (119) du récipient de mélange (102) qui est tangente à une paroi du récipient de mélange (102) pour introduire un tourbillon dans le fluide dans le récipient de mélange (102).

**14.** Procédé selon la revendication 13, dans lequel la génération de la surface de roulement comporte la

projection du fluide solvant incident hors de la buse (118) à travers la poche de gaz et l'entraînement de gaz de la poche de gaz dans le mélange liquide à une profondeur égale ou supérieure à la moitié d'un rayon (R) du récipient de mélange (102).

**15.** Procédé selon la revendication 13 ou la revendication 14, dans lequel l'entraînement de gaz dans le mélange liquide comporte l'entraînement d'un volume de gaz allant de 2 à 20 fois un volume de liquide du fluide solvant incident.

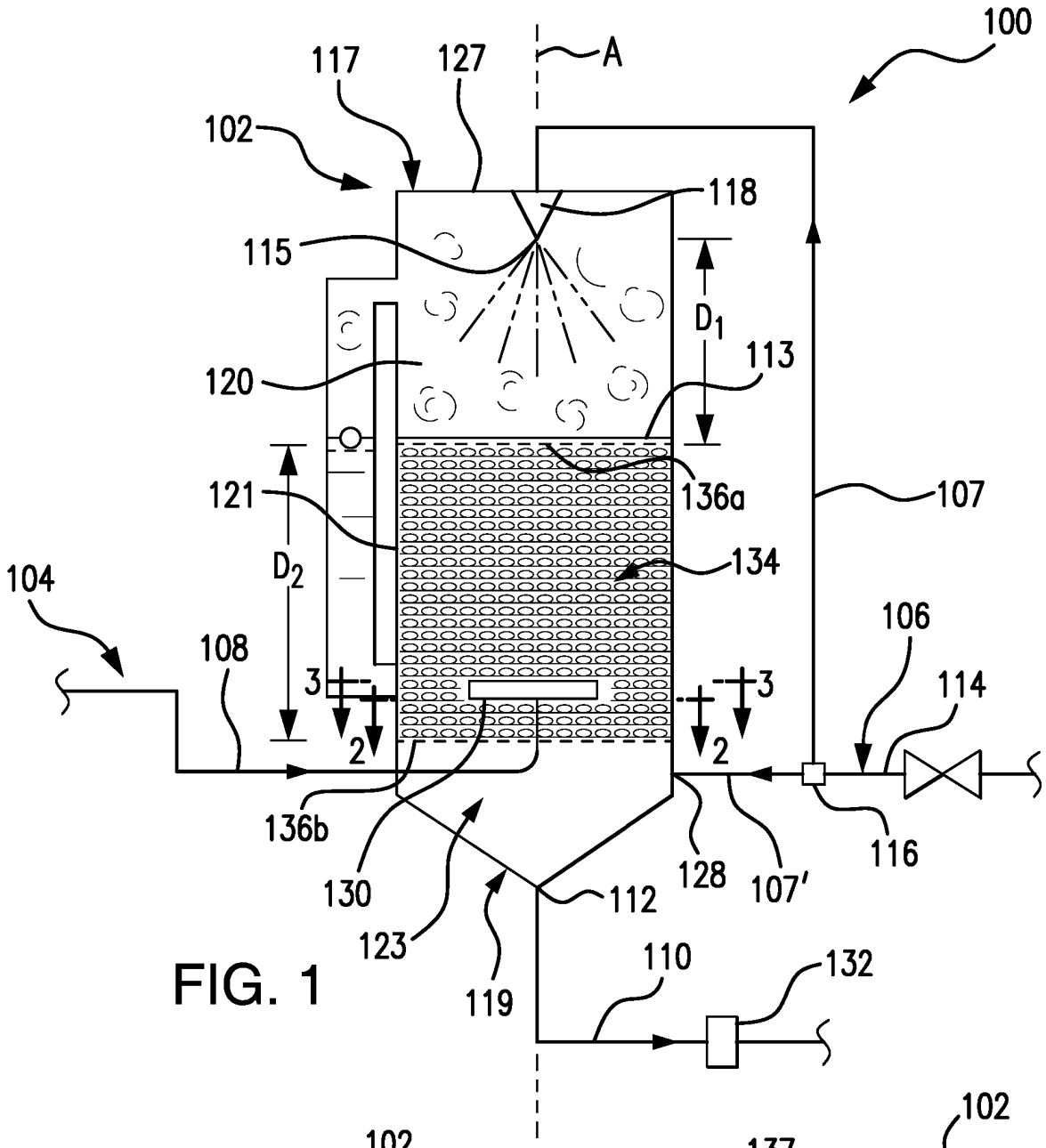



FIG. 1

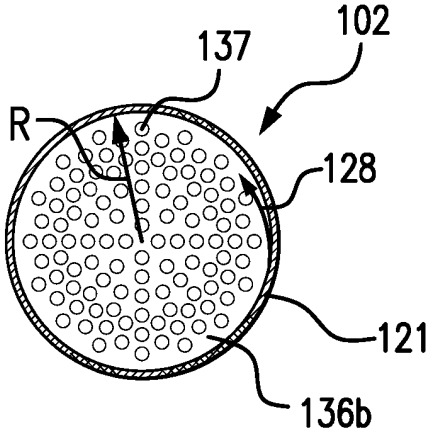



FIG. 2

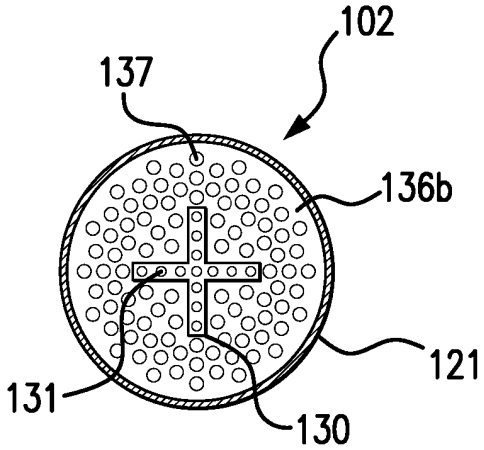



FIG. 3

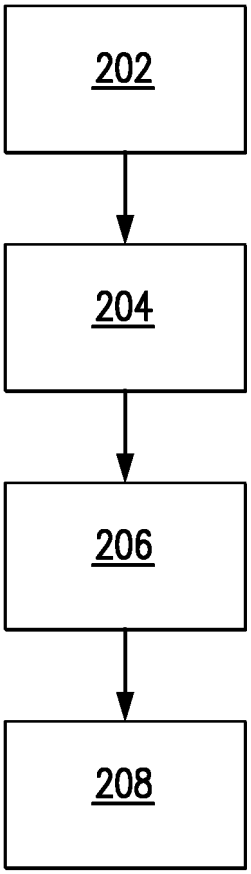



FIG. 4

## REFERENCES CITED IN THE DESCRIPTION

*This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.*

### Patent documents cited in the description


- US 86809415 **[0001]**
- US 4850269 A **[0006] [0008]**
- NL 9001805 **[0006]**