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(54) Title: PROCESS AND APPARATUS FOR GAS-ENRICHING A LIQUID

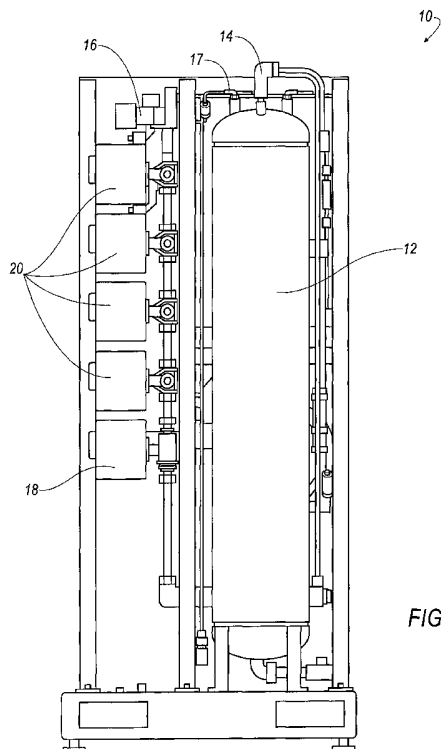


FIG. 1

(57) Abstract: Methods and apparatuses are described for enriching a first liquid with a gas and introducing the gas-enriched first liquid into a second liquid. In an embodiment, the apparatus (10) comprises a vessel (12) containing the gas at an elevated pressure, a liquid fluid inlet (14) into the vessel (12) such that the first liquid enters the vessel and becomes enriched with the gas, a variable internal valve (18) defining an opening through which the gas-enriched first liquid flows after exiting the vessel (12), the internal valve opening adapted to generate bubbles of the gas within the gas-enriched first liquid as the gas-enriched first liquid flows therethrough, and a tube (22) through which the gas-enriched first liquid flows into the second liquid, the tube (22) comprising an inlet section (24) comprising an inlet (26), a coiled section (28) fluidically coupled to the inlet section (24), an outlet section (30) fluidically coupled to the coiled section (28), and an outlet (32) fluidically coupled to the outlet section (30), the tube (22) adapted to maintain the bubbles of the oxygen-containing gas generated within the gas-enriched first liquid by the valve means (18).



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PROCESS AND APPARATUS FOR GAS-ENRICHING A LIQUID

BACKGROUND

[0001] This disclosure generally relates to fluid treatment apparatuses, and more particularly to a process and apparatus capable of enriching a liquid with a gas and introducing the gas-enriched liquid into a second liquid.

[0002] Systems are known that make use of liquids enriched with a gas. For example, U.S. Patent No. 2,713,026 to Kelly et al. appears to disclose the use of a gas-enriched fluid for wastewater treatment, and in particular the introduction of an air-supersaturated fluid into a pool of wastewater to suspend solids in the wastewater and facilitate their removal. Another example is U.S. Patent No. 4,192,742 to Bernard et al., which appears to teach that the biodegradation of wastewater can be promoted by treating the wastewater within a treatment chamber maintained at a pressure above atmospheric pressure to achieve super oxygenation of the wastewater.

[0003] Methods and equipment for enriching a liquid with a gas are also known. For example, U.S. Patent No. 3,957,585 to Malick appears to disclose that atomized liquid can be introduced into a reaction zone to effect intimate contact of the atomized liquid with a gas phase. A particular type of atomizing spray head for this purpose is disclosed in U.S. Patent Application Serial No. 13/602,793 to Eppink et al., filed September 4, 2012, whose contents are fully incorporated herein by reference ("Eppink"). As explained in Eppink et al., such spray heads are adapted to introduce an atomized fluid (for example, potable water or sewage water) into a chamber containing oxygen at a high pressure, with the result that the fluid becomes saturated with oxygen. The oxygen-saturated fluid can then be introduced into a stream of wastewater with the result that the wastewater contains sufficiently high levels of oxygen to promote the activity of aerobic microorganisms capable of biodegrading waste in the wastewater.

[0004] U.S. Patent Nos. 7,008,535 and 7,294,278, each to Spears et al., appear to disclose that a gas-supersaturated fluid can be introduced into a

wastewater so that the gas-supersaturated liquid is introduced in a substantially bubble-free manner. For this purpose, Spears et al. discloses the use of one or more fluid exit nozzles containing capillaries through which the gas-supersaturated liquid can be injected into the wastewater. U.S. Patent No. 7,294,278 to Spears et al. discloses capillaries having diameters of about 150 to about 450 micrometers in nozzles having a plate-like construction, and capillary diameters of about 0.005 inch (about 125 micrometers) in nozzles having a more conventional spray head-type configuration. A drawback of the capillaries is that they may be prone to becoming plugged by solids and reaction products that may be entrained within the gas-supersaturated fluid.

SUMMARY

[0005] Methods and apparatuses are described for enriching a first liquid with a gas and introducing the gas-enriched first liquid into a second liquid. In an embodiment, the apparatus comprises a vessel containing the gas at an elevated pressure, a liquid fluid inlet into the vessel such that the first liquid enters the vessel and becomes enriched with the gas, a variable internal valve defining an opening through which the gas-enriched first liquid flows after exiting the vessel, the internal valve opening adapted to generate bubbles of the gas within the gas-enriched first liquid as the gas-enriched first liquid flows therethrough, and a tube through which the gas-enriched first liquid flows into the second liquid, the tube comprising an inlet section comprising an inlet, a coiled section fluidically coupled to the inlet section, an outlet section fluidically coupled to the coiled section, and an outlet fluidically coupled to the outlet section, the tube adapted to maintain the bubbles of the oxygen-containing gas generated within the gas-enriched first liquid by the valve.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] Various embodiments of the present invention together with arrangement given illustrative purposes only will now be described, by way of example only, and with reference to the accompanying drawings in which:

[0007] FIG. 1 depicts an apparatus for enriching a liquid with a gas and which is adapted to further introduce the enriched liquid-gas combination into a second liquid; and

[0008] FIGs. 2A – 2E depict a tube, in accordance with an implementation.

DETAILED DESCRIPTION

[0009] FIG. 1 depicts an apparatus 10 for enriching a liquid with a gas, and which is adapted to further introduce the enriched liquid-gas combination into a second liquid. The apparatus 10 is particularly well suited for enriching a liquid (for example, water or wastewater) with a gas (for example, oxygen or an oxygen-containing gas) to produce a gas-enriched liquid. In an implementation, the liquid enriched gas is enriched with oxygen, which can thereafter be introduced into a wastewater for the purpose of promoting the activity of aerobic microorganisms capable of biodegrading waste in the wastewater. In various implementations, the apparatus 10 can also be used to enrich liquids with other types of gases, for example, to enrich water or wastewater with ozone gas (O₃) to produce an emulsion of ozone gas-enriched liquid that can then be introduced into wastewater for the purpose of sterilization, or to enrich water or wastewater with nitrogen gas (N₂) to produce a nitrogen gas-enriched liquid that can then be introduced into water or wastewater for the purpose of nitrification. The invention should not be limited to the exemplary embodiments discussed herein and while examples have been provided to illustrate the enriched gas could be enriched with oxygen, ozone, nitrogen hydrogen and the like, other gases are contemplated as well.

[0010] In an implementation, the gas-enriched liquid contains the gas at sufficiently high levels to enable the subsequent generation of bubbles of the gas within the gas-enriched liquid. In an implementation, the apparatus 10 is adapted so that bubbles of a desired quantity and size are generated in a controlled manner within the gas-enriched liquid prior to the liquid being introduced into the second liquid (for example, wastewater).

[0011] With continued reference to FIG. 1, in an embodiment, the apparatus 10 comprises a pressurized vessel 12 and a fluid inlet 14 through which liquid to be enriched with the gas enters the vessel 12. In an embodiment, the liquid is atomized, for example, using an atomizing spray head of the type disclosed in Eppink. In an implementation, such a spray head (not shown) may be located within the vessel 12, which is pressurized with the desired enrichment gas (e.g. air or oxygen) to facilitate the absorption of the enrichment gas within the atomized liquid from the spray head. FIG. 1 represents the enrichment gas as being supplied to the vessel 12 through a valve 16 and supply tube 17. In the example where the enrichment gas is oxygen, the valve 16 supplies oxygen to the vessel 12 so that oxygen within the vessel 12 is at a sufficiently high pressure so that liquid introduced into the vessel 12 through the spray head becomes supersaturated with oxygen.

[0012] In an implementation, the gas-enriched liquid accumulates within the vessel 12 at a level within a prescribed range before being withdrawn from the vessel 12. The effect of maintaining the gas-enriched liquid at an appropriate level within the vessel 12 is to promote the ability of the atomized liquid to absorb and retain the enrichment gas. In an implementation, including the apparatus 10 of FIG. 1, the gas-enriched liquid is maintained within the vessel 12 at a volumetric level of substantially at or between 30 percent and 70 percent of the total internal volume within the vessel 12. Levels below this range may cause excessive off-gassing, and levels above this range may yield inadequate head space to complete gas absorption. A more preferred range is about 40 to about 60 volume percent, and a level of about fifty volume percent has proven to be effective as well.

[0013] In an implementation, the gas-enriched liquid is drawn from the vessel 12 through an analog valve 18 that has an opening (not shown) that can be selectively sized (i.e., provide a variable internal valve opening) between a completely closed state up to and including a maximum size for the opening. In an implementation, the valve 18 is operated so that its valve opening causes bubbles to be generated in the gas-enriched liquid as it is drawn from the vessel 12. As a non-limiting example, if oxygen is used as the enrichment gas, the gas-

enriched liquid is water supersaturated with oxygen, and liquid flow through the valve 18 is at a rate of substantially at or between about 15-20 gallons/minute, the valve 18 can be partially opened to generate an effective volume fraction of bubbles in a size range of substantially at or between about 100 to about 200 micrometers in diameter. In an implementation, to optimize control of the volume fraction and size of the bubbles, the valve 18 is controlled with an electronic controller (not shown), which can use feedback from appropriate sensors (not shown) to control the volume fraction and size of the bubbles.

[0014] In an implementation, one or more zone valves 20 are provided downstream from the valve 18. After exiting the valve 18, the gas-enriched liquid containing the entrained bubbles can be delivered to various applications via the one or more of zone valves 20. In the example in which the enrichment gas is oxygen and the intended use of the gas-enriched liquid is to biodegrade waste in wastewater and create dense separation for decanting, the one or more zone valves 20 are used to route the gas-enriched liquid for introduction into one or more bodies or streams of wastewater (not shown) to promote the activity of aerobic microorganisms. To maintain the volume fraction and size of bubbles generated with the analog valve 18, the gas-enriched liquid and its entrained bubbles are introduced into the wastewater through a tube 22 of a type represented in FIGs. 2A – 2E. In an implementation and as shown in FIGs. 2A – 2E, the tube 22 comprises an inlet section 24, an inlet fitting 26 at the entrance to the inlet section 24 for fluidically coupling (directly or indirectly) the tube 22 to an outlet of the apparatus 10 (for example, one of the valves 20), a spiraled coil section 28, and an outlet section 30 that terminates with an outlet 32. In an implementation, the coil section 28 comprises three complete coils 34. In an implementation, each of the coil diameters are substantially equal. Non-equal coil diameters are contemplated hereby and the invention should not be so limited to three equal coil diameters. In an implementation, the inlet and outlet sections 26 and 30 are substantially straight and parallel to each other. The entire tube 22 preferably has a constant internal diameter.

[0015] In an implementation, the length and internal diameter of the tube 22 and the diameter and number of coils 34 within the coil section 28 are preferably

selected so that flow of the gas-enriched liquid through the tube 22 is laminar which, in combination with surface friction within the coil section 28, is believed to maintain the entrainment of the bubbles in the gas-enriched liquid. For this purpose, suitable lengths and diameters for the tube 22, suitable numbers of coils 34, and suitable diameters for the coil section 28 will depend in part on the pressure and flow velocity of the gas-enriched liquid through the tube 22 and the saturation level of the gas in the liquid. In practice, suitable results have been obtained with an exemplary tube 22 having a total length of substantially at or between about 24 to about 48 inches and an internal diameter of larger than substantially at or between about 0.05 and 0.15 inches (e.g., at or about 0.10 inches), when used in combination with a coil section 28 having three coils 34 and a generally constant coil diameter of substantially at or between about 1.5 to about 2 inches.

[0016] While the disclosure hereof has described a method and product in terms of a specific embodiment, it is apparent that other forms could be adopted by one skilled in the art. For example, the apparatus 10 and its components could differ in appearance and construction from the embodiment shown in the Figures, the functions of each component of the apparatus 10 could be performed by components of different construction but capable of a similar (though not necessarily equivalent) function, and various processes and materials could be employed to manufacture the apparatus 10 and its components. Accordingly, it should be understood that the invention is not limited to the specific embodiment illustrated in the Figures. It should also be understood that the phraseology and terminology employed above are for the purpose of disclosing the illustrated embodiment, and do not necessarily serve as limitations to the scope of the invention. Finally, while the appended claims recite certain aspects believed to be associated with the invention, they do not necessarily serve as limitations to the scope of the invention.

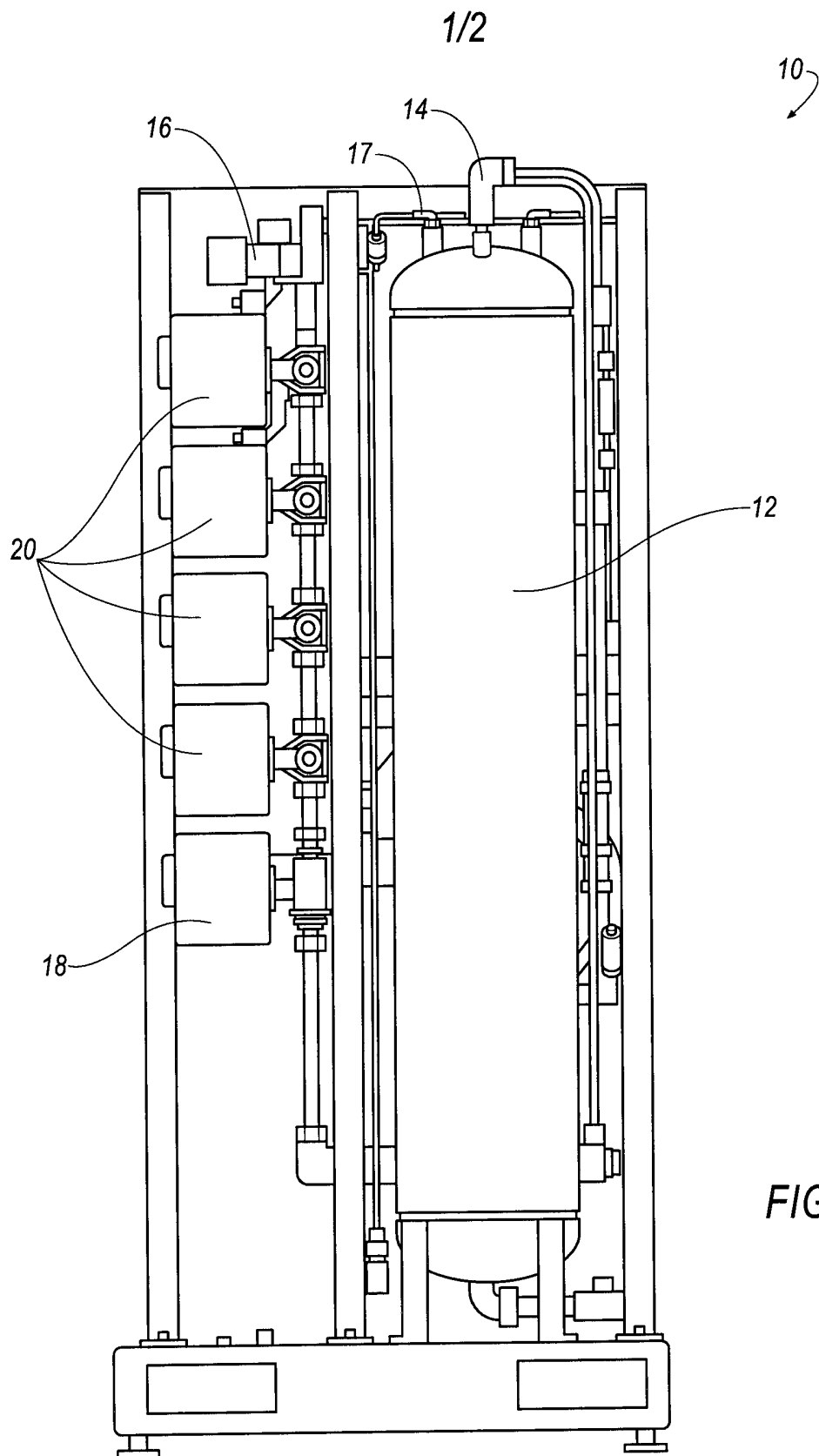
CLAIM(S):

What is claimed is:

1. An apparatus (10) for enriching a first liquid with a gas and introducing the gas-enriched first liquid into a second liquid, the apparatus (10) comprising:
 - a vessel (12) containing the gas at an elevated pressure;
 - a liquid fluid inlet (14) into the vessel (12) such that the first liquid enters the vessel and becomes enriched with the gas;
 - a variable internal valve (18) defining an opening through which the gas-enriched first liquid flows after exiting the vessel (12), the internal valve opening selectively opened to generate bubbles of the gas within the gas-enriched first liquid as the gas-enriched first liquid flows therethrough; and
 - a tube (22) through which the gas-enriched first liquid flows into the second liquid, the tube (22) comprising an inlet section (24) comprising an inlet (26), a coiled section (28) fluidically coupled to the inlet section (24), an outlet section (30) fluidically coupled to the coiled section (28), and an outlet (32) fluidically coupled to the outlet section (30), the tube (22) adapted to maintain the bubbles of the oxygen-containing gas generated within the gas-enriched first liquid by the valve means (18).
2. The apparatus (10) according to claim 1, wherein the inlet and outlet sections (26,30) of the tube (22) are straight.
3. The apparatus (10) according to claim 2, wherein the inlet and outlet sections (26,30) of the tube (22) are parallel.
4. The apparatus (10) according to claim 1, wherein the coiled section (28) of the tube (22) has a constant coil diameter.
5. The apparatus (10) according to claim 1, wherein the tube (22) has a constant internal diameter.

6. The apparatus (10) according to claim 1, wherein the tube (22) has an internal diameter of substantially at or between about 1 mm and 4 mm.
7. The apparatus (10) according to claim 1, wherein the gas is an oxygen-containing gas.
8. The apparatus (10) according to claim 1, wherein the gas is a nitrogen-containing gas.
9. The apparatus (10) according to claim 1, wherein the first liquid is water or wastewater.
10. The apparatus (10) according to claim 1, wherein the second liquid is wastewater.
11. A process comprising:
 - causing a first liquid to become enriched with a gas;
 - generating bubbles of the gas within the gas-enriched first liquid; and
 - flowing the gas-enriched first liquid and the bubbles therein into a second liquid through a tube (22), the gas-enriched first liquid flowing through, in sequence, an inlet section (24), a coiled section (28), an outlet section (30), and an outlet (32) of the tube (22) so as to retain the bubbles of the gas generated within the gas-enriched first liquid.
12. The process according to claim 11, wherein the inlet and outlet sections (26,30) of the tube (22) are straight.
13. The process according to claim 12, wherein the inlet and outlet sections (26,30) of the tube (22) are parallel.

14. The process according to claim 11, wherein the coiled section (28) of the tube (22) has a constant coil diameter.
15. The process according to claim 11, wherein the tube (22) has a constant internal diameter.
16. The process according to claim 11, wherein the tube (22) has an internal diameter of substantially at or between about 1 mm and 4 mm.
17. The process according to claim 11, wherein the gas is a nitrogen-containing gas.
18. The process according to claim 11, wherein the gas is an oxygen-containing gas.
19. The process according to claim 18, wherein the first liquid is water or wastewater.
20. The process according to claim 19, wherein the second liquid is wastewater and the gas-enriched first liquid promotes the activity of aerobic microorganisms capable of biodegrading waste in the wastewater.



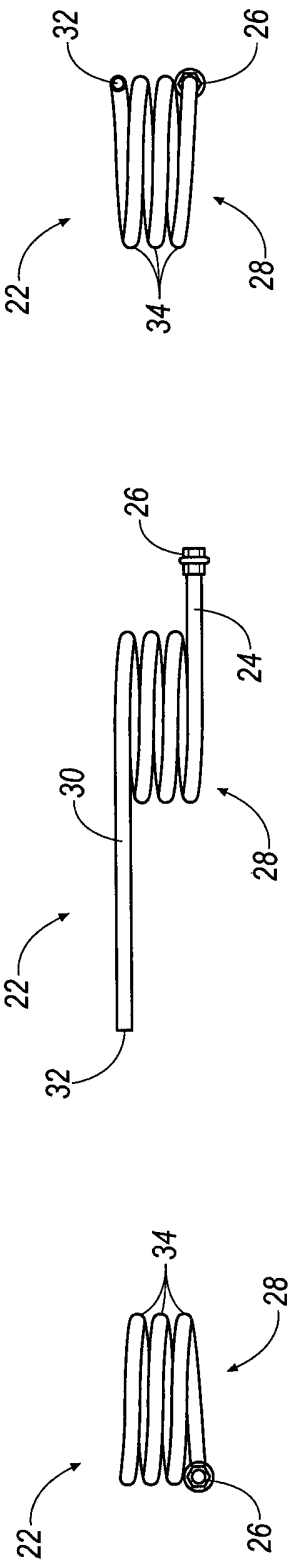


FIG. 2A

FIG. 2B

FIG. 2C

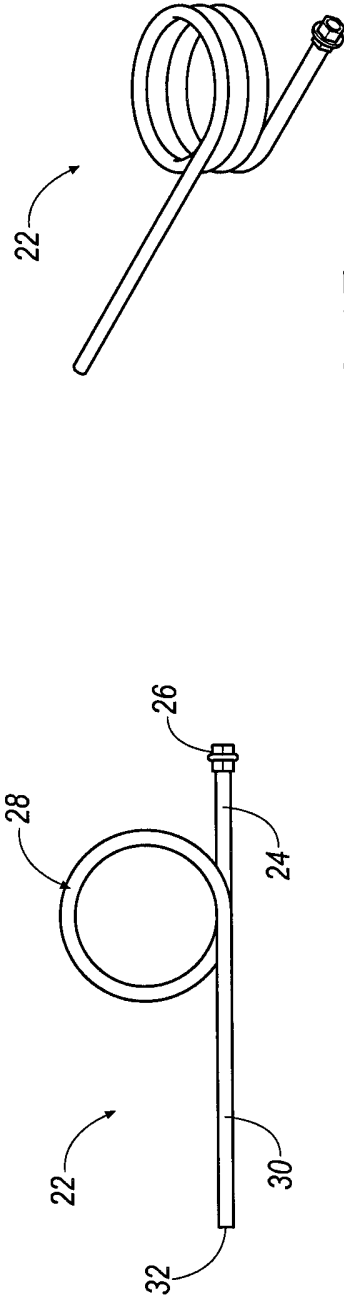


FIG. 2D

FIG. 2E

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2012/064663

A. CLASSIFICATION OF SUBJECT MATTER

INV. B01F3/04 B01F3/08 C02F3/12
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B01F C02F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 7 294 278 B2 (SPEARS J R [US] ET AL SPEARS J RICHARD [US] ET AL) 13 November 2007 (2007-11-13) cited in the application column 10, line 48 - column 15, line 55; figures 1-3,7,11	1-20
Y	----- US 5 938 983 A (SHEAFFER RONALD C [US] ET AL) 17 August 1999 (1999-08-17) column 5, lines 59-62 column 6, lines 6-12 figures 1-3	1-20
A	----- US 5 015 394 A (MCELLHENNEY COLBURN [US] ET AL) 14 May 1991 (1991-05-14) figures 1-5 column 3, line 44 - column 4, line 44 -----	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

8 February 2013

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 7294278	B2	13-11-2007	AT 537894 T 15-01-2012
			DK 1313548 T3 30-01-2012
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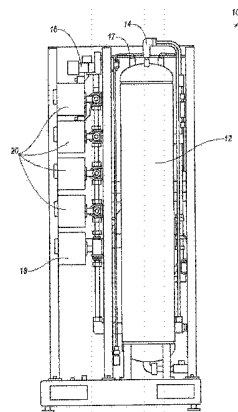
权利要求书2页 说明书3页 附图2页

(54) 发明名称

用于富集气体的液体的方法和装置

(57) 摘要

描述了一种用于使第一液体富集有气体并将富集气体的第一液体引入到第二液体中的方法和装置。在实施方式中,装置(10)包括容器(12),其包含处于高压的气体;进入容器(12)的液体流体入口(14),以使得第一液体进入容器并变得富集有气体;可变内阀门(18),其限定开口,富集气体的第一液体在排出容器(12)之后流动通过所述开口,内阀门开口适于在富集气体的第一液体流动通过时在富集气体的第一液体产生气体的气泡;以及管(22),富集气体的第一液体流动通过管(22)进入第二液体,所述管(22)包括包含入口(26)的入口部分(24)、流体耦接至入口部分(24)的线圈部分(28)、流体耦接至线圈部分(28)的出口部分(30)以及流体耦接至出口部分(30)的出口(32),所述管(22)适于通过阀门装置(18)保持在富集气体的第一液体产生的包含氧气的气体的气泡。



1. 一种用于使第一液体富集有气体并将富集气体的第一液体引入到第二液体中的装置 (10), 所述装置 (10) 包括:

容器 (12), 其包含处于高压的气体;

进入容器 (12) 的液体流体入口 (14), 以使得第一液体进入容器并变得富集有气体;

可变内阀门 (18), 其限定开口, 富集气体的第一液体在排出容器 (12) 之后流动通过所述开口, 内阀门开口选择性地打开, 以在富集气体的第一液体流动通过时在富集气体的第一液体中产生气体的气泡; 以及

管 (22), 富集气体的第一液体流动通过管 (22) 进入第二液体, 所述管 (22) 包括包含入口 (26) 的入口部分 (24)、流体耦接至入口部分 (24) 的线圈部分 (28)、流体耦接至线圈部分 (28) 的出口部分 (30) 以及流体耦接至出口部分 (30) 的出口 (32), 所述管 (22) 适于通过阀门装置 (18) 保持在富集气体的第一液体内产生的包含氧气的气体的气泡。

2. 根据权利要求 1 所述的装置 (10), 其中所述管 (22) 的入口和出口部分 (26, 30) 是笔直的。

3. 根据权利要求 2 所述的装置 (10), 其中所述管 (22) 的入口和出口部分 (26, 30) 是平行的。

4. 根据权利要求 1 所述的装置 (10), 其中所述管 (22) 的线圈部分 (28) 具有不变的线圈直径。

5. 根据权利要求 1 所述的装置 (10), 其中所述管 (22) 具有不变的内部直径。

6. 根据权利要求 1 所述的装置 (10), 其中所述管 (22) 具有基本上处于或在大约 1mm 和 4mm 之间的内部直径。

7. 根据权利要求 1 所述的装置 (10), 其中所述气体是包含氧气的气体。

8. 根据权利要求 1 所述的装置 (10), 其中所述气体是包含氮气的气体。

9. 根据权利要求 1 所述的装置 (10), 其中所述第一液体是水或废水。

10. 根据权利要求 1 所述的装置 (10), 其中所述第二液体是废水。

11. 一种方法, 包括:

使第一液体变成富集有气体;

在富集气体的第一液体中产生气体的气泡, 以及

使富集气体的第一液体及其中的气泡通过管 (22) 流动到第二液体中, 富集气体的第一液体依次流动通过管 (22) 的入口部分 (24)、线圈部分 (28)、出口部分 (30) 和出口 (32), 以容纳在富集气体的第一液体中产生的气体的气泡。

12. 根据权利要求 11 所述的方法, 其中所述管 (22) 的入口和出口部分 (26, 30) 是笔直的。

13. 根据权利要求 12 所述的方法, 其中所述管 (22) 的入口和出口部分 (26, 30) 是平行的。

14. 根据权利要求 11 所述的方法, 其中所述管 (22) 的线圈部分 (28) 具有不变的线圈直径。

15. 根据权利要求 11 所述的方法, 其中所述管 (22) 具有不变的内部直径。

16. 根据权利要求 11 所述的方法, 其中所述管 (22) 具有基本上处于或在大约 1mm 和 4mm 之间的内部直径。

17. 根据权利要求 11 所述的方法,其中所述气体是包含氮气的气体。
18. 根据权利要求 11 所述的方法,其中所述气体是包含氧气的气体。
19. 根据权利要求 18 所述的方法,其中所述第一液体是水或废水。
20. 根据权利要求 19 所述的方法,其中所述第二液体是废水,以及富集气体的第一液体促进能够使废水中的废物生物降解的嗜氧微生物的活性。

用于富集气体的液体的方法和装置

技术领域

[0001] 本公开文本大体涉及一种流体处理装置,并且更具体地,涉及一种能够使液体富集有气体并将富集气体的液体引入第二液体中的方法和装置。

背景技术

[0002] 使用富集有气体的液体的系统是已知的。例如, Kelly 等人的美国专利 No. 2, 713, 026 看上去公开了将富集气体的流体用于废水处理,并且更具体地,将过饱和和空气的流体引入到废水池中以使固体悬浮在废水中并且促进它们的移动。另一个例子是 Bernard 等人的美国专利 No. 4, 192, 742, 其看上去教导了通过在使压力保持超过大气压力的处理腔室中处理废水以获得废水的超氧化作用而促进废水的生物降解。

[0003] 使液体富集有气体的办法和设备也是已知的。例如, Malick 的美国专利 No. 3, 957, 585 看上去公开了可以将雾化液体引入到反应区域中以影响雾化液体与气相的紧密接触。在 2012 年 9 月 4 日提交的 Eppink 等人的美国专利申请系列号 No. 13/602, 793 中公开了用于该目的的特定类型的雾化喷头,其内容通过引用(“Eppink”)完全并入本文。如 Eppink 等人解释的,这种喷头适于在高压下将雾化流体(例如,饮用水或者污水)引入饱含氧气的腔室中,因此流体变得饱含氧气。然后,饱含氧气的流体被引入到废水流束中,因此废水充分含有高度氧气以促进能够使废水中废物生物降解的嗜氧微生物的活性。

[0004] Spears 等人的美国专利 No. 7, 008, 535 和 No. 7, 294, 278 看上去公开了可以将气体过饱和的流体引入到废水中,以使得以基本上无气泡的方式引入气体过饱和的流体。为此, Spears 等人公开了使用一个或多个包括毛细管的流体排出喷嘴,气体过饱和的流体可以通过毛细管注入到废水中。Spears 等人的美国专利 No. 7, 294, 278 公开了在具有板状结构的喷嘴中的毛细管具有大约 150 至大约 450 微米的直径,以及在具有更常规喷头型配置的喷嘴中的毛细管直径为大约 0.005 英寸(大约 125 微米)。该毛细管的缺点在于它们可能容易被可以进入气体过饱和的流体中的固体和反应物堵塞。

发明内容

[0005] 描述了一种使第一液体富集有气体并将富集气体的第一液体引入到第二液体中的方法和装置。在实施方式中,装置包括:容器,其包含处于高压的气体;进入容器的液体流体入口,以使得第一液体进入容器并变得富集有气体;可变内阀门,其限定开口,富集气体的第一液体在排出容器之后流动通过所述开口,内阀门开口适于在富集气体的第一液体流动通过时在富集气体的第一液体中产生气体的气泡;以及管,富集气体的第一液体流动通过管进入第二液体,所述管包括包含入口的入口部分、流体耦接至入口部分的线圈部分、流体耦接至线圈部分的出口部分以及流体耦接至出口部分的出口,所述管适于通过阀门保持在富集气体的第一液体内产生的包含氧气的气体的气泡。

附图说明

[0006] 现在,仅通过实例并参考附图描述本发明的各个实施方式以及给出说明性目的的布置,其中:

[0007] 图 1 示出了使液体富集气体并适于进一步将富集液体-气体的组合物引入到第二液体中的装置;以及

[0008] 图 2A-2E 根据实施例示出了管。

具体实施方式

[0009] 图 1 示出了用于使液体富集气体并适于进一步将富集流体-气体的组合物引入到第二液体中的装置 10。该装置 10 尤其很好地适合于使液体(例如,水或废水)富集气体(例如,氧气或含氧气体)以产生富集气体的液体。在实施例中,富集气体的流体富集有氧气,其然后被引入到废水中以用于促进能够使废水中的废物生物降解的嗜氧微生物的活性。在各个实施例中,装置 10 还用来使液体富集有其他类型的气体,以例如使水或废水富集有臭氧气体(O_3),从而产生然后能够被引入到废水中以进行杀菌的富集臭氧气体的液体的乳剂,或者以使水或废水富集有氮气(N_2),从而产生然后能够被引入到水或废水中以进行硝化作用的富集氮气的液体。本发明不应该限于本文讨论的示例性实施方式,同时已经提供了实例来说明富集的气体应该富集有氧气、臭氧、氮气、氢气等,也可以预期其他气体。

[0010] 在实施例中,富集气体的液体包含足够高程度的气体以在富集气体的液体中随后产生气体的气泡。在实施例中,装置 10 适合于使得在将液体引入到第二液体中之前(例如,废水),以受控方式在富集气体的液体中产生期望数量和尺寸的气泡。

[0011] 继续参照附图 1,在实施方式中,装置 10 包括加压容器 12 和流体入口 14,富集有气体的液体通过该流体入口进入容器 12。在实施方式中,例如使用 Eppink 中公开的那种类型的雾化喷头使液体雾化。在实施例中,这种喷头(未示出)可以定位在容器 12 中,容器被用期望的富集气体(例如,空气或氧气)加压以有利于从喷头吸收雾化液体中的富集气体。图 1 表示富集气体通过阀门 16 和供应管 17 供应至容器 12。在富集气体是氧气的实例中,阀门 16 将氧气供应至容器 12,以使得容器 12 内的氧气处于足够高的压力,从而使得通过喷头引入到容器 12 中的液体变得对于氧气过饱和。

[0012] 在实施例中,富集气体的液体在被从容器 12 排出之前,以规定范围内的程度积聚在容器 12 中。使富集气体的液体以合适程度保持在容器 12 中的作用在于促进雾化液体吸收和容纳富集气体的能力。在包含图 1 的装置 10 的实施例中,富集气体的液体以基本上处于或在容器 12 内的总内体积的 30%和 70%之间的体积程度保持在容器 12 内。低于该范围的程度可能导致过多的废气排放,而高于该范围的程度可能产生不足以完成气体吸收的顶部空间。更优选的范围在大约 40%至大约 60%体积,也已经验证过大约 50%体积的程度是有效的。

[0013] 在实施例中,富集气体的液体通过模拟阀门 18 从容器 12 排出,模拟阀门 18 具有开口(未示出),该开口能够在完全闭合状态直至包括用于开口的最大尺寸之间被选择性地制定尺寸(即,提供可变的内阀门开口)。在实施例中,阀门 18 被操作,以使得当富集气体的液体从容器 12 中排出时,其阀门开口导致将在富集气体的液体中产生气泡。作为非限制性实例,如果将氧气用作富集气体,那么富集气体的液体是过饱和有氧气的水,并且液体流过阀门 18 的速率基本上处于或在大约 15-20 加仑/分钟之间,阀门 18 可以部分打开,以

产生直径的尺寸范围基本上处于或在大约 100 至大约 200 微米的气泡的有效体积分数。在实施例中,为了使气泡的体积分数和尺寸的控制最佳化,用电子控制器(未示出)控制阀门 18,该电子控制器使用来自适当的传感器(未示出)的反馈来控制气泡的体积分数和尺寸。

[0014] 在实施例中,从阀门 18 向下游设置一个或多个区域阀门 20。在排出阀门 18 之后,可以通过区域阀门 20 中的一个或多个将包含携带的气泡的富集气体的液体传送给多个应用。在富集气体是氧气并且富集气体的液体的有意使用是为了生物降解废水中的废物并产生重液分离以进行倾倒的实例中,使用一个或多个区域阀门 20 来传送富集气体的液体以引入到一个或多个废水主体或流束(未示出)中,从而促进嗜氧微生物的活性。为了保持利用模拟阀门 18 产生的气泡的体积分数和尺寸,将富集气体的液体及其携带的气泡通过图 2A-2E 表示的类型管 22 引入到废水中。在图 2A-2E 所示的实施例中,管 22 包括入口部分 24、在入口部分 24 的进口处用于将管 22 流体(直接或间接地)耦接至装置 10 的出口(例如,阀门 20 中的一个)的入口配件 26、螺旋形线圈部分 28 以及利用出口 32 终止的出口部分 30。在实施例中,线圈部分 28 包括三个完整的线圈 34。在实施例中,线圈直径中的每个基本上相等。在此预期不相等的线圈直径,并且本发明不应该受限于三个相等的线圈直径。在实施例中,入口和出口部分 26 和 30 基本上是笔直的并且相互平行。整个管 22 优选地具有不变的内部直径。

[0015] 在实施例中,管 22 的长度和内部直径以及线圈部分 28 中的线圈 34 的直径和数量被优选地选择,以使得富集气体的液体通过管 22 的流动是层状的,其与线圈部分 28 中的表面摩擦结合,被认为保持富集气体的液体中的气泡的携带。为此,管 22 的合适长度和直径、线圈 34 的合适数量以及线圈部分 28 的合适直径将部分取决于富集气体的液体通过管 22 的压力和流动速度以及液体中气体的饱和程度。实践中,当结合具有三个线圈 34 并且具有基本上处于或在大约 1.5 至大约 2 英寸之间的大致不变的线圈直径的线圈部分 28 使用时,已经利用示例性管 22 获得了该合适的结果,这种示例性管 22 具有基本上处于或在大约 24 至大约 48 英寸的总长度和基本上大于处于或在大约 0.05 和 0.15 英寸之间(例如,处于或大约 0.10 英寸)的内部直径。

[0016] 虽然本公开文本已经根据特定实施方式描述了方法和产品,但是显而易见的是,所属领域技术人员能够采用其他形式。例如,装置 10 及其组件可以在外形和结构上与附图所示的实施方式不同,可以通过不同结构但能够具有类似(当然没有必要相同)功能的组件执行装置 10 的每个组件的功能,并且可以使用各种方法和材料制备装置 10 及其组件。因此,应该理解,本发明并不限于附图所示的特定实施方式。也应该理解,以上所使用的措词和术语出于公开图示的实施方式的目的,不必用作本发明的范围的限制。最后,虽然所附权利要求列举了被认为与本发明相关的某些方面,但是它们并不必然地用作对本发明的范围的限制。

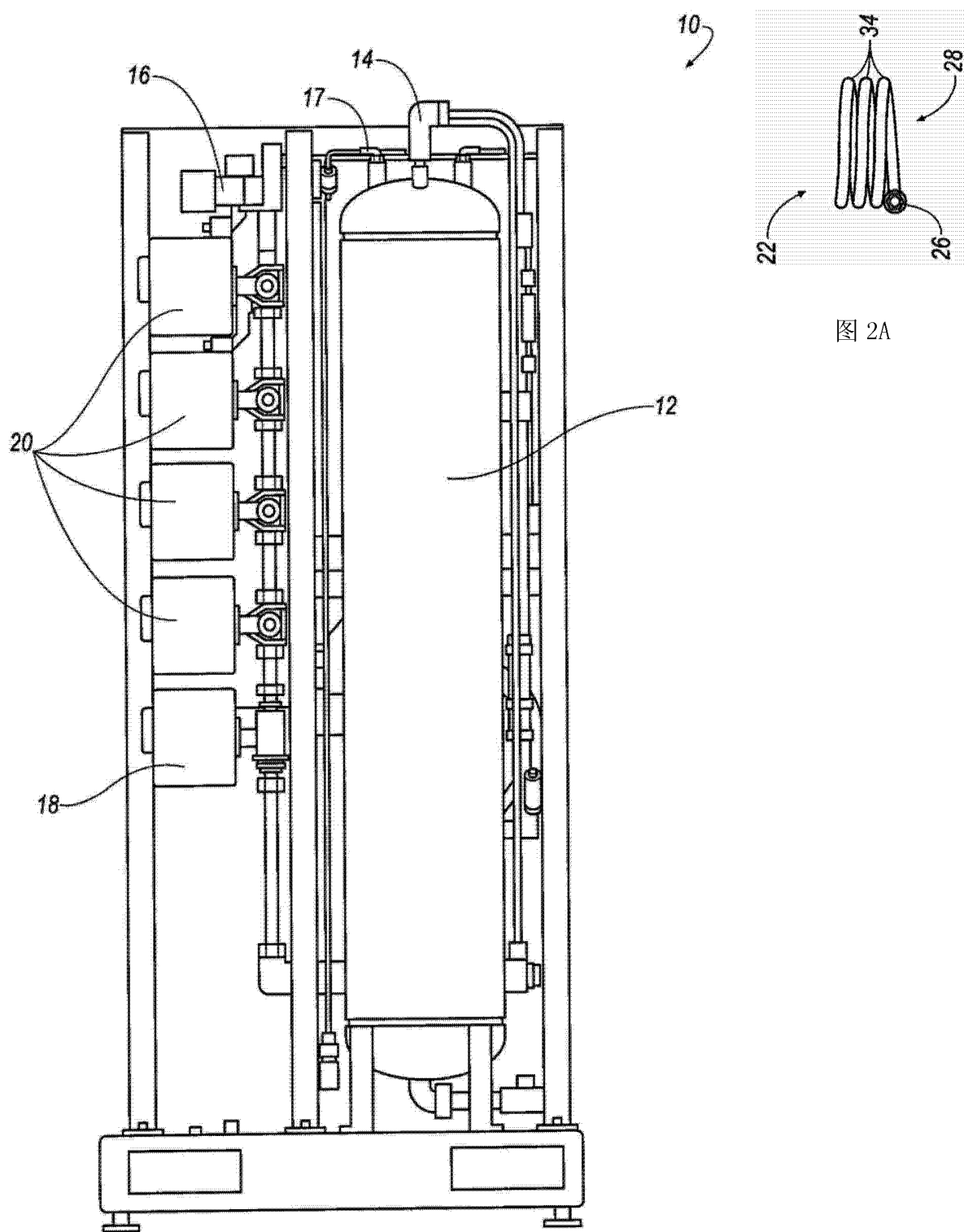


图 1

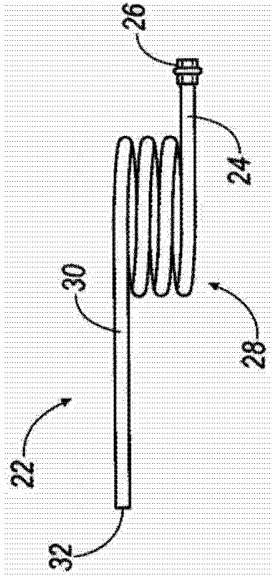


图 2B

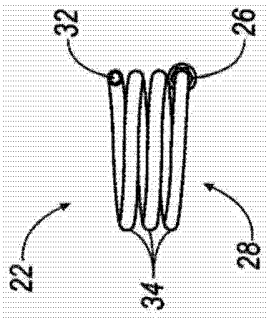


图 2C

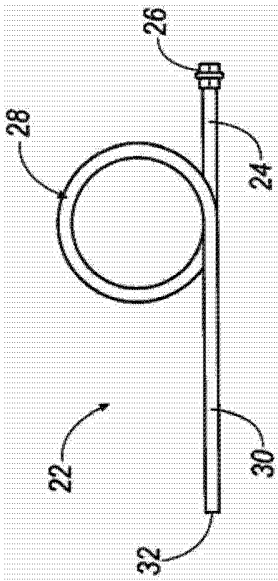


图 2D

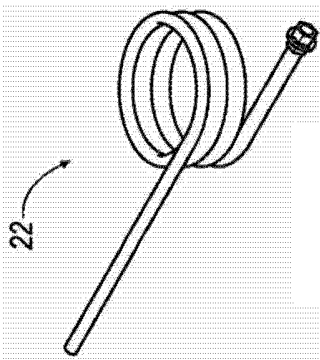


图 2E