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

(11) EP 2 060 318 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
15.09.2010 Bulletin 2010/37

(51) Int Cl.:
B01F 3/04 *(2006.01)* ***B01F 5/04*** *(2006.01)*
B01F 5/06 *(2006.01)*

(21) Application number: **08165901.3**

(22) Date of filing: **06.10.2008**

(54) **Apparatus and method for generating and distributing bubbles in a gas-liquid mixture**

Vorrichtung und Verfahren zur Erzeugung und Verteilung von Blasen in einer Gas-Flüssigkeitsmischung

Appareil et procédé pour générer et distribuer des bulles dans un mélange gaz-liquide

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

(30) Priority: **15.11.2007 NO 20075910**

(43) Date of publication of application:
20.05.2009 Bulletin 2009/21

(73) Proprietor: **YARA International ASA**
0202 Oslo (NO)

(72) Inventors:
- **Reines, Arnfinn**
  3930 Porsgrunn (NO)
- **Bekken, Svein**
  3721 Skien (NO)
- **Emilsen, Morten**
  0973 Oslo (NO)

(74) Representative: **Onsagers Ltd**
c/o Innovation Norway
5 Lower Regent Street
London SW1Y 4LR (GB)

(56) References cited:
EP-A- 1 749 564
SU-A3- 1 790 558
US-A- 5 810 052
US-A1- 2004 251 566

EP 2 060 318 B1

Description

[0001] The invention concerns an apparatus and a method for generating and distributing bubbles in a gas-liquid mix transported in a flow path of a pipe.

[0002] The object of the invention is to obtain an efficient dissolution and/or distribution of gas in liquid during the transport in the pipe. A further object of the invention is to reduce the size of the initial bubbles in the liquid and provide for the bobbles to be distributed in the flow.

[0003] Methods and apparatus for providing smaller sized bubbles to dissolve gas in liquid may be applied in different technical fields. The dissolution of oxygen in water is of special interest for the present invention, even if the invention is applicable to other ranges of use wherein different kinds of gases and liquids may be part of the current process. Water to be used for fish farms has a need for oxygen to be dissolved in the water transported through a pipe into ponds or tanks for the inhabitation of fish. The production and distribution of smaller sized bubbles in accordance with the invention, provides advantageous for dissolving oxygen in water. Even if fish farms are of special interest, the invention is applicable within other technical fields, such as for instance addition of gas (e.g. oxygen or carbon dioxide) to waste water, potable water and various process fluids.

[0004] Devices for the generation of micro bubbles are described in prior art such as JP 2006326484. The apparatus disclosed in this publication has a box shaped structure divided into three compartments. A gas-liquid mix is introduced through an inlet into to the first compartment and the mixture flows from the first into the second and from the second into the third compartment, via small holes made in the common wall between two and two compartments. The small holes generate micro bubbles in the liquid and the flow leaves the box structure through an outlet arranged in the third compartment.

[0005] Due to the configuration of the device of JP 2006326484 a significant loss of pressure occurs when mixture passes through the device. The velocity of the mixture leaving the outlet is low and the risk for coalescing of the bubbles is therefore substantial. If this device were to be used in the same application as the invention, given the condition that the mixture flowing out from the outlet needs to have a certain pressure level, an additional pump needs to be installed in the third compartment, to maintain the working pressure in the pipe arrangement wherein the invention is to be installed. The installation of an additional pump increases the level of costs as well as the need for maintenance.

[0006] The apparatus in accordance with the present invention has a cheap and fairly uncomplicated construction and no parts such as an additional pump needing frequent overhauling, in addition to increased operating cost, as the loss of pressure in the apparatus is low and the flow is transported through the apparatus utilizing the existing pressure in the flow path. Further, the device of JP 2006326484 has an inlet and an outlet arranged in an angular relation ship, the device of JP 2006326484 would therefore not be suitable for adaptation into an inline arrangement with an elongated pipe arrangement as is the focus of the present invention. In the device of JP 2006326484, the gas is dissolved in the liquid when the mixture passes through the device due to the size of the volume captured in the device and the retention period the mix endures in the device, whereas the main object of the inventive apparatus is to provide smaller sized bubbles and obtain an even distribution of these in the flow. When using the present invention the dissolution process occurs in several steps, a part of the dissolution process occurs prior to the flow entering the apparatus in accordance with the invention, a further part of the dissolution process occurs in the apparatus and the completion of the process occurs after the flow leaving the apparatus, for instance in the fish pond. The size of the holes between the compartments of device disclosed in JP 2006326484, renders the device vulnerable to clogging by leaves, sticks etc entering the device.

[0007] Reference should also be made to the publications US 6982968, WO 01/36105 and JP 2003117365.

[0008] US 6982968 shows a nozzle device for the treatment of waste water, wherein the object of the invention concerns the release and rise of micro bubbles from the liquid. Thus the object of the invention of US 6982968 then being the opposite of the object of the present invention, as an important aspect of the invention is to avoid the accumulation of smaller sized bubbles at the top area of the flow and to maintain an even distribution of smaller sized bubbles across the cross section of the flow.

[0009] WO 01/36105 shows a nozzle arranged with holes of different size for the introduction of liquid and gas into a pipe element. The publication does not concern the disintegrating of bubbles into smaller bubbles or obtaining a certain disposition of bubbles in the flow.

[0010] JP 2003117365 concerns the reduction of bubbles into micro bubbles by the use of a pump providing the stirring and pressurizing of a gas liquid mix. This method is not applicable to the present invention.

[0011] Other prior art devices are disclosed in US 2004/0251566 and US 5810052.

[0012] US 2004/0251566 discloses a device for generating micro bubbles, wherein the device comprises multiple cavitation generators. The device in its various embodiments has an inlet for liquid and a passage for inlet of gas down stream the liquid inlet. The passage for inlet of gas is arranged so that gas is supplied into the first cavitation generator which may be a baffle or other constrictions to the fluid path, and is mixed with the liquid at this location. Down stream the first cavitation generator, a first cavitation field is generated. The flow thereafter enters a second cavitation generator, and downstream the second cavitation generator a second cavitation field is generated. Any number of stages of hydrodynamic cavitation can provided within the flow channel of the bubble genereating device of US 2004/025 1566.

[0013] US 5810052 discloses an apparatus for mixing two liquids such as oil and water. Given that this device is provided for the mixing of oil and water, high pressure conditions are needed for obtaining mixing between the two liquids. The pressure drop over the apparatus of D2 is quite large and the object of the apparatus is to produce conditions for utilizing the cavitation effect.

[0014] The object of the invention is obtained by the apparatus as defined in the independent apparatus claim and the independent method claim. Further embodiments of the invention is defined in the following dependent claims.

[0015] In accordance with the first independent claim an apparatus for providing and distributing bubbles in a gas-liquid mix transported in a fluid path in a pipe is provided. The apparatus is arranged in line with the pipe and comprises in successive order an inlet region, an obstacle unit and an outlet region. The inlet region is arranged for the entering of the gas-liquid mix containing initial sized bubbles, and further the inlet region is provided to accelerate and direct the flow into the obstacle unit. The obstacle unit is provided with structure elements to produce a turbulence whereby reducing the initial sized bubbles to smaller sized bubbles and also disperse and distribute the bubbles evenly in the flow. The outlet region is arranged for the entering of the gas-liquid mix containing smaller sized bubbles, and has provisions to accelerate the flow and maintain an even distribution of smaller sized bubbles in the flow for further transport in the pipe.

[0016] In accordance with the second independent claim the invention also includes a method.

[0017] In one embodiment of the invention, the purpose of the apparatus is to produce evenly distributed micro bubbles across the cross section of the flow to achieve effective dissolution of the gas in the liquid. In this embodiment small sized bubbles constitute the initial sized bubbles and micro sized bubbles constitute smaller sized bubbles.

[0018] Different kinds of gas and liquid preferably transported in a mixture may be suitable for the apparatus in accordance with the independent claims. The gas may be present in various states and quantities in the liquid, and the states may vary as the mixture is transported through the apparatus. The gas may be present solely as bubbles in the liquid or the gas may be present both as bubbles and partly dissolved in the liquid. The gas may also be introduced in liquid form. The gas is introduced into the liquid flowing in the flow path of the pipe through for instance a gas inlet situated in the fluid path. Bubbles of an initial size may be generated when the gas is inserted in the liquid. The gas inlet is preferably situated upstream from the entry of the inlet region and would be connected to a gas supply by suitable means

[0019] The pipe wherein the gas-liquid mix is transported comprises at least one pipe element. The pipe may be composed of a number of pipe elements arranged in an elongated relationship making up a pipeline. Each pipe element is formed with at least one flow path, and preferably joined in an end-to-end arrangement. The size, shape, flexibility and material of the individual pipe element may vary, depending on the field of use.

[0020] The apparatus is arranged in an inline relationship with the pipe. The fluid path of the pipe defines a main flow direction. The flow is transported through the apparatus in a direction corresponding to the main flow direction. Contrary to the device of JP 2006326484, when installing the apparatus in an existing pipeline the main flow direction is not altered when the flow travels through the apparatus. The inline arrangement of the inventive apparatus provides for the gas liquid mix to be transported through the apparatus utilizing existing pressure in the pipe.

[0021] Also, the in line arrangement makes the installation of the apparatus in an existing pipe/pipeline quite simple. Preferably, the installation occurs in situ, wherein a part of the pipe is removed and the inventive apparatus is inserted and connected to the remaining parts of the pipe. If the inventive apparatus is to be used in a pipe transporting liquid/gas to a fishpond, the installation may very well be performed by the owner or maintainer of the fish farm, as the installation procedure is quite simple and does not require particular professional skills.

[0022] The apparatus in accordance with the invention contributes to the dissolving of gas in liquid. In one embodiment the dissolving of gas in liquid occurs at various locations during the transport through the pipe and inventive apparatus. A portion of the gas inserted into the liquid may be dissolved upstream from the inlet area. A further portion of the gas may be dissolved during the transport through the apparatus and the remaining portion of the gas may be dissolved downstream from the outlet region, such as during the further transport in the pipe or in a tank, wherein the mouth of the pipe is accommodated. For instance a tank such as the fish pond included in a fish farm.

[0023] The inventive apparatus offers a simple, cost saving and effective alternative to obtain an efficient dissolving of gas, such as oxygen, in liquid, such as water. One or plural of components; the inlet region, the obstructing unit and/or outlet region may be constituted by pre made elements, such as for instance standard elements made of a plastic material or a metallic material.

[0024] In one embodiment a flow obstacle is arranged in a passage of the obstacle unit. The flow obstacle is arranged in such a way that at least one opening appears between the flow obstacle and the passage wall. The flow obstacle may be constituted by a structural element fixed by suitable means in the passage leaving one or more openings between element and the passage wall for the flow to pass through. By the introduction of the flow obstacle which preferably is arranged with an appointed flow stop area positioned essentially in the centre of the passage, the flow hits the flow obstacle and is forced in a direction transverse to the main flow direction before passing through the opening(s), preferably arranged at the perimeter of the flow obstacle. Due to the

occurrences brought about by the impact on the flow obstacle a turbulence is produced downstream of the flow obstacle causing a reduction of the initial sized bubbles to smaller sized bubbles and also dispersing the bubbles in the flow.

[0025] The flow obstacle may by provided by various structures, wherein the arrangement of a structure of solid material arranged in the centre of the passage leaving an opening for the flow to pass at the perimeter of the structure, provides the basis for achieving a turbulence. The flow obstacle may by provided by a disk shaped structure arranged with one or more openings preferably through bores. The bore(s) is/are preferably arranged in vicinity of the perimeter of the disk and the centre portion of the disk constitutes the flow stop area. Alternatively, the flow obstacle is made with a cross shaped cross section with arms of generally the same length and an intersection being generally circular shaped making up the flow stop area. (The area of the arms may be included in the flow stop area). In another embodiment an elongated element, for instance a pipe element, arranged in the obstacle unit makes up the flow obstacle. The elongated element may be arranged transverse to the main flow direction such that at least one opening is provided between the passage wall and the flow obstacle.

[0026] The size of the flow obstacle or the flow stop area and the openings are worked out based on the pressure available in the flow path. The total open area of the flow obstacle is calculated based on the total desired and/or available pressure drop over the unit. This total open area is then distributed on one ore more openings so that the total open area of the flow obstacle , and thus the pressure drop, is unchanged. The inlet region may be arranged with various provisions to accelerate and direct the flow into the obstacle unit. In one embodiment, the inlet region is arranged with a passage provided to reduce the size of the cross section of the flow passing through the inlet, thereby obtaining an accelerating effect. The inlet region may be formed as a venturi like element.

[0027] Further, the outlet region may be arranged as a structure similar to the inlet region. In one embodiment, the outlet region is arranged with a passage provided to reduce the size of the cross section of the flow passing through the outlet, thereby obtaining an accelerating effect. The outlet region may be formed as a venturi like element.

[0028] In the following an example of the invention will be described with reference to the attached drawings wherein:

Fig 1 shows a first embodiment of the invention.
Fig 2 shows a first embodiment of the invention arranged in a pipe element.
Fig 3 shows a second embodiment of the invention.
Fig 4 shows the invention arranged in a pipe assembly.
Fig 5 shows a third embodiment of the invention.

Fig 1 shows the apparatus 1 comprising an inlet region 2, an obstacle unit, in the figure shown as a turbulence chamber 3 and an outlet region 4. A flow of liquid is transported in a flow path 6. The liquid flow is illustrated by arrows. Arrow 5a shows a main flow direction of the flow path 6. Gas is introduced in the pipe by a gas supply 7a feeding gas into the liquid through a gas inlet 7b, such as a gas diffuser or other suitable equipment. The gas is shown in the flow path 6 as dots 8 illustrating gas bubbles, preferably bubbles having a small size. The mix of liquid and gas enters the inlet region 2, here shown as a venturi like element, being formed with a narrow passage opening into a conical increasing and decreasing passage respectively. This narrow passage of the inlet region 2 ensures a fairly good concentration of gas bubbles across the cross section of the flow and accelerates the flow aiming for a flow obstacle 12 arranged in the turbulence chamber 3.

[0029] The flow obstacle 12 is shown as a plate or disc element provided with openings 10 such as through bores. Four openings 10 are shown arranged in vicinity to the perimeter of the flow obstacle 12 in fig 1. The number and the size of the diameter and length of the opening may vary in accordance for instance with the diameter of the pipe, the use of material, pressure available in the pipe and other design criterias. The flow obstacle 12 has an appointed flow stop area 11 provided by a solid portion of the disc structure positioned essentially centred around the axial axis of the pipe. The flow hits the flow stop area 11 in a main flow direction and experiences a change in flow direction. The impact of the flow on the flow stop area 11, forces the flow in a direction transverse to the main flow direction towards the perimeter of the flow obstacle 12, before assuming main flow direction passing through the openings 10. This causes an initial reduction of the bubble size. A zone of turbulence arises downstream from the flow obstacle 12 illustrated by arrows 5b, causing a further reduction of the size of the bubbles preferably to micro sized bubbles, and dispersing the bubbles across the cross section of the pipe. The liquid gas mix thereafter enters the outlet region 4, here shown as a venturi like element, being formed with a narrow passage opening into a conical increasing and decreasing passage respectively. In the outlet region 4 the flow is accelerated causing and maintaining an even distribution of bubbles across the cross section of the flow to avoid the accumulation of bubbles at the top and ensure efficient contact surfaces between the liquid and gas bubbles for further transport in the pipe.

[0030] In fig 2 the apparatus 1 of fig 1, is shown built up by several pipe elements with a cover pipe 14 arranged around the pipe elements. The pipe elements making up the apparatus 1 are standard element for instance made of some kind of plastic or metallic material. The flow obstacle 12 may also be provided by a standard element, for instance a metal plate.

[0031] Fig 3 shows a second embodiment of the apparatus 1, wherein the inlet region 24, the outlet region 26 and the flow obstacle 22, all are constituted by disc or plate elements with screw holes 30 providing fixing points for the elements. The other elements in the figure correspond generally to the elements in fig. The disc elements of the inlet and outlet regions 24, 26 respectively are each arranged with a passage providing a restriction in the flow path. The inlet region 24, outlet region 26 and the flow obstacle 22 according to the second embodiment have the same functions and causes the same effects on the flow as mentioned in the description of inlet and outlet regions 2, 4 and flow obstacle 22 above. The flow obstacle 22 has a cross shaped cross section with arms having generally the same length and an intersection having a generally circular shape making up the flow stop area 21. The arms define openings 20 for the flow to pass through.

[0032] In fig 4 the apparatus 1 with the cover pipe as shown in fig 2 is shown installed in a tube or pipe such as pipe 15. The apparatus 1 is shown in an inline arrangement with the pipe 15. When installing the apparatus 1, the existing pipe line is divided into separated parts. The apparatus 1 is positioned in between the parts and each end of the apparatus 1 is connected to the separated parts of the pipe 15. The installation procedure occurs in situ and is fairly straight forward. As the installation is quite simple it might be carried out and maintained by the fish farmer, making installation and service persons redundant in most cases. The arrangement shown in fig 4 is an arrangement to be used in a fish farm. The pipe 15 carries water (fresh water or salt water) illustrated by arrow 16 and oxygen is inserted through the gas inlet 7 to be dissolved in the water. The end of the pipe 15 is shown submerged in a fish tank 18 and is provided with outlets for the flow of water/gas mix dispersed with micro sized bobbles. Portions of oxygen may be dissolved in the liquid before the flow enters the apparatus 1, further portions are dissolved in the liquid in the apparatus 1 and after leaving the apparatus 1. After leaving the apparatus the dissolution may occur in the pipe 15 or/and in the fish tank 18. A similar installation principle may be used for other purposes than the said oxygen for fish farming. One example is the addition of carbon dioxide to high pH wastewater prior to sewer outlet.

[0033] Fig 5 shows the apparatus 1 in accordance with a third version of the invention, wherein the inlet region 2 and the outlet region 4 correspond to those shown in fig 1. The embodiment of the flow obstacle arranged in the turbulence chamber 3 comprises a pipe element 31 positioned so that two openings 30 appear for the flow to pass through. The central axis 32 of the pipe element 31 is shown with an orientation transverse to the main flow direction 5b. The pipe element 31 may be arranged with its central axis 32 perpendicular to both the main flow direction 5a and the central axis 32 as displayed in fig 5. The use of a (rounded) pipe element as flow obstacle gives reduced pressure loss compared to a flat surface.

Claims

1. An apparatus (1) for providing and distributing bubbles(8) in a gas-liquid mix transported in a flow path (6) of a pipe, the apparatus is arranged in line with the pipe and comprises in successive order an inlet region (2), an obstacle unit (3) and an outlet region (4)wherein

   - the inlet region (2) is arranged for the entering of gas-liquid mix containing initial sized bubbles, the inlet region (2) is provided to accelerate and direct the flow into
   - the obstacle unit (3) provided with structure elements to produce a turbulence whereby reducing the initial sized bubbles to smaller sized bubbles and dispersing the bubbles in the flow, and a flow obstacle (12) is arranged in a passage of the obstacle unit (3), providing at least one opening between the flow obstacle (12) and passage wall, wherein the flow obstacle has an appointed flow stop area (21) positioned essentially in the centre of the passage, providing at least one opening between the flow obstacle (12) and the wall of the passage,
   - the outlet region (4 is arranged for the entering of the gas-liquid mix containing smaller sized bubbles and has provisions to accelerate the flow and maintain an even distribution of smaller sized bubbles in the flow for further transport in the pipe.

2. An apparatus according to claim 1, **characterized in that** the initial sized bubbles comprise small sized bubbles and/or the smaller sized bubbles comprise microsized bubbles

3. An apparatus according to one of the claims 1 or 2, **characterized in that** the flow obstacle (12) comprises a disk shaped structure arranged with one or more openings preferably through bores, preferably the bore(s) is/are arranged in vicinity of the perimeter of the disk.

4. An apparatus according to one of the claims 1 or 2, **characterized in that** the flow obstacle (12) has a cross shaped cross section with arms of generally the same length and an intersection being generally circular shaped.

5. An apparatus according to one of the claims 1 or 2, **characterized in that** the flow obstacle comprises an elongated element, in particular a pipe element (31).

6. An apparatus according to one of the proceeding claims,
characterized in that the size of the flow stop area and/or the number of openings are worked out based on the pressure drop available over the flow obstacle.

7. An apparatus according to one of the proceeding claims,
characterized in that the inlet region and/or the outlet region each have a passage provided to reduce the size of the cross section of flow to pass through the passage.

8. An apparatus according to one of the proceeding claims,
characterized in that the inlet region and/or the outlet region are formed as an venturi like element.

9. An apparatus according to one of the proceeding claims,
characterized in that t a gas inlet is situated upstream from the entry of the inlet region.

10. An apparatus according to one of the proceeding claims,
characterized in that the inlet region and/or the obstructing unit and/or the outlet region are provided by premade elements

11. An apparatus according to one of the proceeding claims,
characterized in that the pipe transports liquid/gas mix to a tank, such as a fish pond (18) included in a fish farm.

12. An apparatus according to one of the proceeding claims,
characterized in that a portion of the gas inserted into the liquid is dissolved upstream from the inlet area, a further portion of the gas is dissolved during the transport through the apparatus and the remaining part of the gas is dissolved downstream from the outlet region.

13. An apparatus according to one of the proceeding claims,
characterized in that the liquid comprises water and/or the gas comprises oxygen.

14. Method for providing and distributing bubbles in a gas-liquid mix transported in a pipe, by use of an apparatus (1) in accordance with one of the claims 1-13, wherein the apparatus is arranged in line with the pipe and comprises in successive order an inlet region (2), an obstacle unit (3) and an outlet region (4), comprising the following steps:

- the gas-liquid mix containing initial sized bubbles enters the inlet region (2), wherein provisions of the inlet region (2) accelerates and directs the flow into
- the obstacle unit (3)provided with structure elements produces a turbulence whereby reducing the initial sized bubbles to smaller sized bubbles and dispersing the bubbles in the flow, thereafter
- the gas-liquid mix containing smaller sized bubbles enters the outlet region (4) wherein the provisions of the outlet region (4) accelerate the flow and maintain an even distribution of smaller sized bubbles in the flow for further transport in the pipe.

Patentansprüche

1. Vorrichtung zum Erzeugen und Verteilen von Blasen (1) in einer Gas-Flüssigkeits-Mischung, die in einem Strömungsweg (6) eines Rohres transportiert wird, wobei die Vorrichtung in Reihe mit dem Rohr angeordnet ist und der Reihe nach einen Einlaßbereich (2), eine Hinderniseinheit (3) und einen Auslaßbereich (4) aufweist,

- wobei der Einlaßbereich (2) für den Eintritt einer Gas-Flüssigkeits-Mischung ausgelegt ist, die Blasen mit einer Anfangsgröße enthalten, wobei der Einlaßbereich (2) dazu ausgelegt ist, die Strömung zu beschleunigen und einzuleiten in
- die Hinderniseinheit (3), welche mit Strukturelementen zu Erzeugung einer Turbulenz versehen ist, so daß die Blasen mit einer Anfangsgröße reduziert werden auf Blasen mit einer geringeren Größe und die Blasen in der Strömung verteilt werden, wobei ein Strömungshindernis (12) in einer Passage der Hinderniseinheit (3) vorgesehen ist, das zumindest eine Öffnung zwischen dem Strömungshindernis (12) und der Wand der Passage bildet, wobei das Strömungshindernis einen bestimmten Strömungsstoppbereich (21) besitzt, der im wesentlichen im Zentrum der Passage angeordnet ist, wobei mindestens eine Öffnung zwischen dem Strömungshindernis (12) und der Wand der Passage vorgesehen ist,
- wobei der Auslaßbereich (4) für den Eintritt der Gas-Flüssigkeits-Mischung ausgelegt ist, welche die Blasen mit geringerer Größe enthält, und Einrichtungen aufweist, um die Strömung zu beschleunigen und eine gleichmäßige Verteilung der Blasen mit geringerer Größe in der Strömung für den weiteren Transport in den Rohr beizubehalten.

2. Vorrichtung nach Anspruch 1,
dadurch gekennzeichnet,
daß die Blasen mit einer Anfangsgröße Blasen mit kleiner Größe aufweisen und/oder die Blasen mit geringerer Größe Mikrobläschen aufweisen.

3. Vorrichtung nach einem der Ansprüche 1 oder 2,
dadurch gekennzeichnet,
daß das Strömungshindernis (12) eine scheibenförmige Struktur aufweist, die mit einer oder mehreren Öffnungen, vorzugsweise Durchgangsbohrungen ausgebildet ist, wobei die Bohrung(en) in der Nähe des Umfanges der Scheibe angeordnet ist/sind.

4. Vorrichtung nach einem der Ansprüche 1 oder 2,
dadurch gekennzeichnet,
daß das Strömungshindernis (12) einen kreuzförmigen Querschnitt mit Armen, die im allgemeinen die gleiche Länge besitzen, und einer Kreuzung aufweist, die im allgemeinen kreisförmig ausgebildet ist.

5. Vorrichtung nach einem der Ansprüche 1 oder 2,
dadurch gekennzeichnet,
daß das Strömungshindernis ein langgestrecktes Element, insbesondere ein Rohrelement (31) aufweist.

6. Vorrichtung nach einem der vorhergehenden Ansprüche,
dadurch gekennzeichnet,
daß die Größe des Strömungsstoppbereiches und/oder die Anzahl von Öffnungen auf der Basis des verfügbaren Druckabfalls über dem Strömungshindernis eingearbeitet sind.

7. Vorrichtung nach einem der vorhergehenden Ansprüchen,
dadurch gekennzeichnet,
daß der Einlaßbereich und/oder der Auslaßbereich jeweils eine Passage besitzen, die dazu vorgesehen ist, die Größe des Querschnitts der Strömung zu reduzieren, die die Passage durchströmt.

8. Vorrichtung nach einem der vorhergehenden Ansprüche,
dadurch gekennzeichnet,
daß der Einlaßbereich und/oder der Auslaßbereich als venturi-artige Elemente ausgebildet sind.

9. Vorrichtung nach einem der vorhergehenden Ansprüche,
dadurch gekennzeichnet,
daß ein Gaseinlaß stromaufwärts von dem Eingang des Einlaßbereiches positioniert ist.

10. Vorrichtung nach einem der vorhergehenden Ansprüche,
dadurch gekennzeichnet,
daß der Einlaßbereich und/oder die Hinderniseinheit und/oder der Auslaßbereich aus vorgefertigten Elementen vorgesehen sind.

11. Vorrichtung nach einem der vorhergehenden Ansprüche,
dadurch gekennzeichnet,
daß das Rohr die Flüssigkeits-Gas-Mischung in einen Behälter transportiert, beispielsweise einen Fischteich (18), der in einer Fischfarm vorgesehen ist.

12. Vorrichtung nach einem der vorhergehenden Ansprüche,
dadurch gekennzeichnet,
daß ein Teil des Gases, das in die Flüssigkeit eingeführt wird, stromaufwärts von dem Einlaßbereich gelöst wird, ein weiterer Bereich des Gases während des Transportes durch die Vorrichtung gelöst wird und der übrige Teil des Gases stromabwärts von dem Auslaßbereich gelöst wird.

13. Vorrichtung nach einem der vorhergehenden Ansprüche,
dadurch gekennzeichnet,
daß die Flüssigkeit Wasser und/oder das Gas Sauerstoff enthält.

14. Verfahren zum Erzeugen und Verteilen von Blasen in einer Gas-Flüssigkeits-Mischung, die in einem Rohr transportiert wird, und zwar mittels einer Vorrichtung (1) nach einem der Ansprüche 1 bis 13,
wobei die Vorrichtung in Reihe mit dem Rohr angeordnet wird, und in einer Reihenfolge nacheinander einen Einlaßbereich (2), eine Hinderniseinheit (3) und einen Auslaßbereich (4) aufweist,
wobei das Verfahren folgende Schritte aufweist:

- die Gas-Flüssigkeits-Mischung, welche Blasen mit einer Anfangsgröße enthält, tritt in den Einlaßbereich (2) ein, wobei Einrichtungen des Einlaßbereiches (2) die Strömung beschleunigen und einleiten in
- die Hinderniseinheit (3), die mit Strukturelementen versehen sind, welche eine Turbulenz erzeugen, so daß die Blasen mit einer Anfangsgröße reduziert werden in Blasen mit einer geringeren Größe und die Blasen in der Strömung verteilt werden, woraufhin
- die Gas-Flüssigkeits-Mischung, welche die Blasen mit geringerer Größe enthält, in den Auslaßbereich (4) eintritt, wobei die Einrichtungen des Auslaßbereiches (4) die Strömung beschleunigen und eine gleichmäßige Verteilung der Blasen mit geringerer Größe in der Strömung für den Weitertransport in dem Rohr beibehalten.

Revendications

1. Appareil (1) pour apporter et distribuer des bulles (8) dans un mélange gaz-liquide transporté dans un trajet d'écoulement (6) d'un tuyau, l'appareil étant agencé aligné avec le tuyau et comprenant dans un ordre successif une zone d'entrée (2), une unité d'obstacle (3) et une zone de sortie (4) où :

   - la zone d'entrée (2) est arrangée pour l'entrée d'un mélange gaz-liquide contenant des bulles de taille initiale, la zone d'entrée (2) est prévue pour accélérer et diriger l'écoulement dans
   - l'unité d'obstacle (3) munie d'éléments structuraux pour produire une turbulence, rapetissant de ce fait les bulles de taille initiale en bulles de taille inférieure et dispersant les bulles dans l'écoulement, et un obstacle d'écoulement (12) est agencé dans un passage de l'unité d'obstacle (3), fournissant au moins une ouverture entre l'obstacle d'écoulement (12) et la paroi de passage, où l'obstacle d'écoulement possède une zone d'arrêt d'écoulement appropriée (21) positionnée sensiblement au centre du passage, fournissant au moins une ouverture entre l'obstacle d'écoulement (12) et la paroi du passage,
   - la zone de sortie (4) est agencée pour l'entrée du mélange gaz-liquide contenant des bulles de taille inférieure et possède des dispositions pour accélérer l'écoulement et maintenir une distribution homogène des bulles de taille inférieure dans l'écoulement pour un transport ultérieur dans le tuyau.

2. Appareil selon la revendication 1, **caractérisé en ce que** les bulles de taille initiale comprennent des bulles de petite taille et/ou les bulles de taille inférieure comprennent des bulles micronisées.

3. Appareil selon l'une des revendications 1 ou 2, **caractérisé en ce que** l'obstacle d'écoulement (12) comprend une structure en forme de disque où sont ménagées une ou plusieurs ouvertures, de préférence des trous traversants, de préférence le ou les trous est ou sont ménagé(s) au voisinage du périmètre du disque.

4. Appareil selon l'une des revendications 1 ou 2, **caractérisé en ce que** l'obstacle d'écoulement (12) possède une section transversale en forme de croix avec des bras globalement de même longueur et une intersection de forme globalement circulaire.

5. Appareil selon l'une des revendications 1 ou 2, **caractérisé en ce que** l'obstacle d'écoulement comprend un élément allongé, en particulier un élément de tuyau (31).

6. Appareil selon l'une des revendications précédentes, **caractérisé en ce que** la taille de la zone d'arrêt d'écoulement et/ou le nombre d'ouvertures sont réalisés en fonction de la chute de pression disponible au niveau de l'obstacle d'écoulement.

7. Appareil selon l'une des revendications précédentes, **caractérisé en ce que** la zone d'entrée et/ou la zone de sortie possèdent chacune un passage prévu pour réduire la taille de la section transversale d'écoulement à travers le passage.

8. Appareil selon l'une des revendications précédentes, **caractérisé en ce que** la zone d'entrée et/ou la zone de sortie sont formées comme un élément de type Venturi.

9. Appareil selon l'une des revendications précédentes, **caractérisé en ce qu'**une entrée de gaz est située en amont de l'entrée de la zone d'entrée.

10. Appareil selon l'une des revendications précédentes, **caractérisé en ce que** la zone d'entrée et/ou l'unité d'obstruction et/ou la zone de sortie sont munies d'éléments préfabriqués.

11. Appareil selon l'une des revendications précédentes, **caractérisé en ce que** le tuyau transporte un mélange liquide/gaz vers un réservoir, tel qu'un étang à poissons (18) inclus dans un établissement de pisciculture.

12. Appareil selon l'une des revendications précédentes, **caractérisé en ce qu'**une partie du gaz inséré dans le liquide est dissoute en amont de la zone d'entrée, une autre partie du gaz est dissoute durant le transport à travers l'appareil et la partie restante du gaz est dissoute en aval de la zone de sortie.

13. Appareil selon l'une des revendications précédentes, **caractérisé en ce que** le liquide comprend de l'eau et/ou le gaz comprend de l'oxygène.

14. Procédé pour générer et distribuer des bulles dans un mélange gaz-liquide transporté dans un tuyau, par l'utilisation d'un appareil (1) selon l'une des revendications 1 à 13, où l'appareil est agencé aligné avec le tuyau et comprend dans un ordre successif une zone d'entrée (2), une unité d'obstacle (3) et une zone de sortie (4), comprenant les étapes suivantes :

   le mélange gaz-liquide contenant des bulles de taille initiale pénètre dans la zone d'entrée (2), où des dispositions de la zone d'entrée (2) accélèrent et dirigent l'écoulement dans
   l'unité d'obstacle (3) munie d'éléments structuraux produit une turbulence, rapetissant de ce fait les bulles de taille initiale en bulles de taille

inférieure et dispersant les bulles dans l'écoulement, ensuite
le mélange gaz-liquide contenant des bulles de taille inférieure pénètre dans la zone de sortie (4) où les dispositions de la zone de sortie (4) accélèrent l'écoulement et maintiennent une distribution homogène des bulles de taille inférieure dans l'écoulement pour un transport ultérieur dans le tuyau.

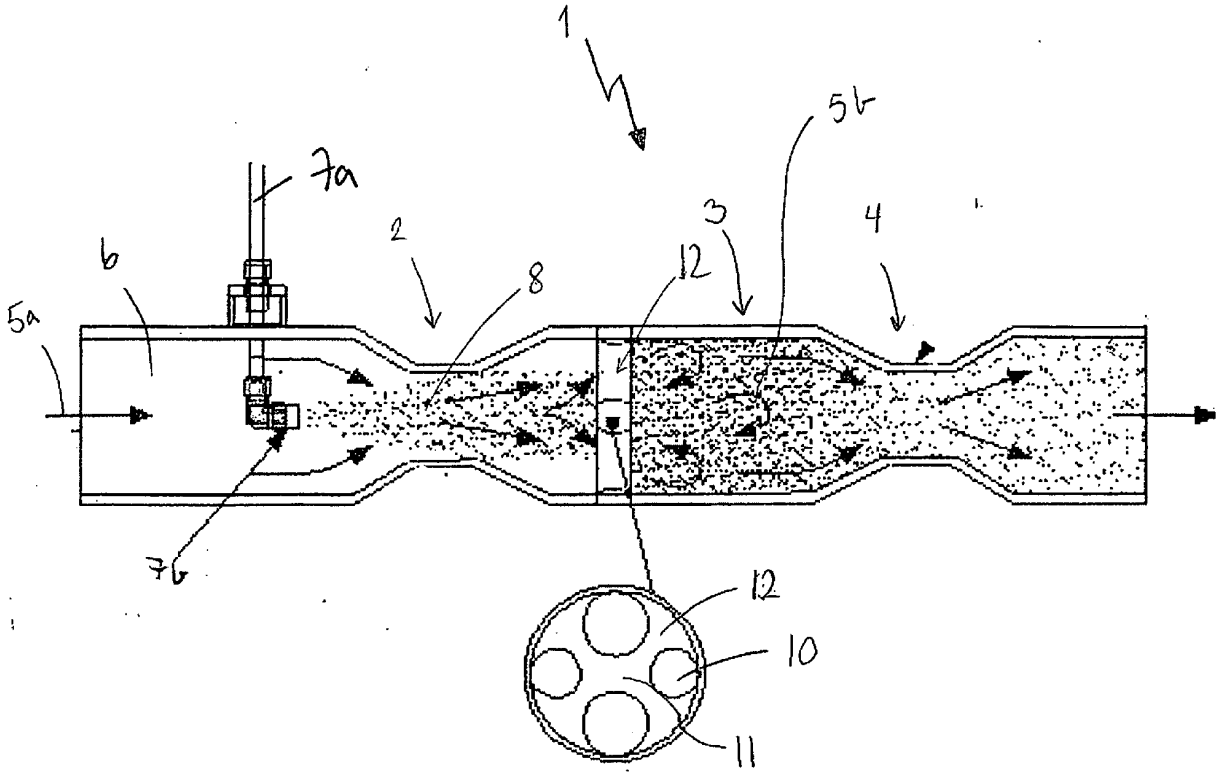

Fig 1

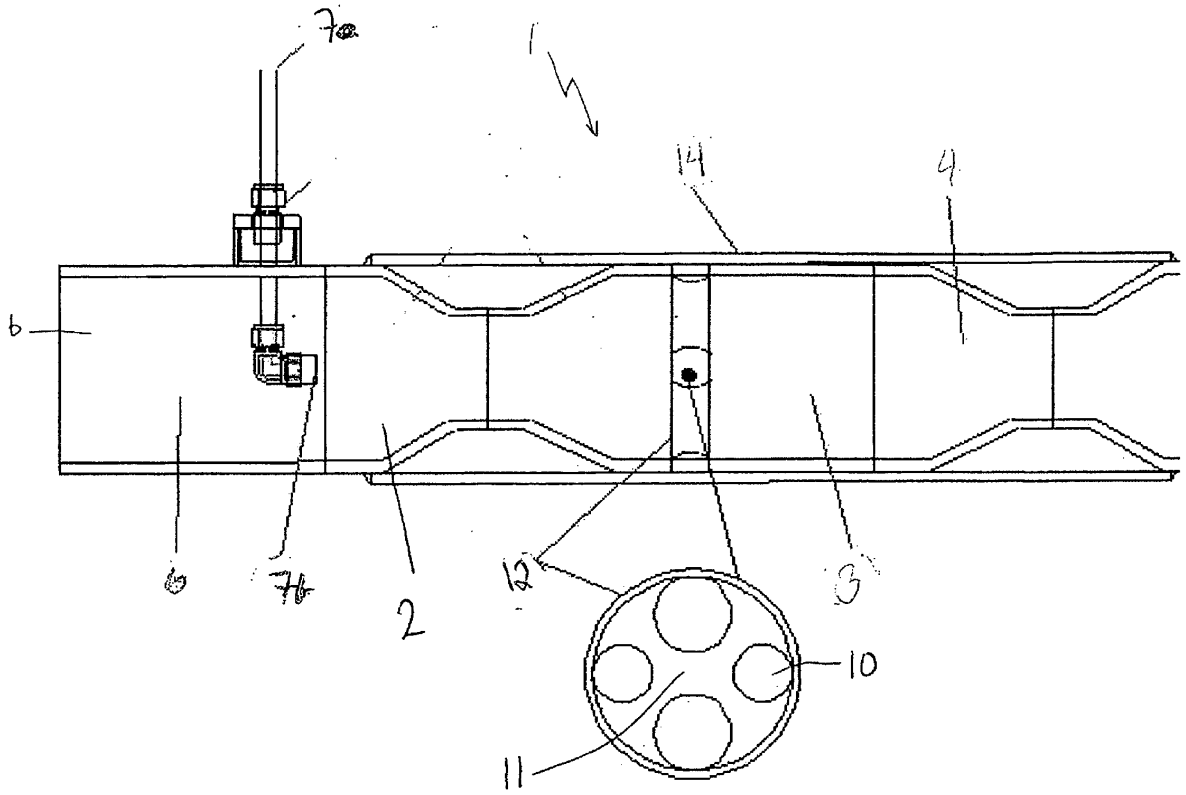

Fig 2

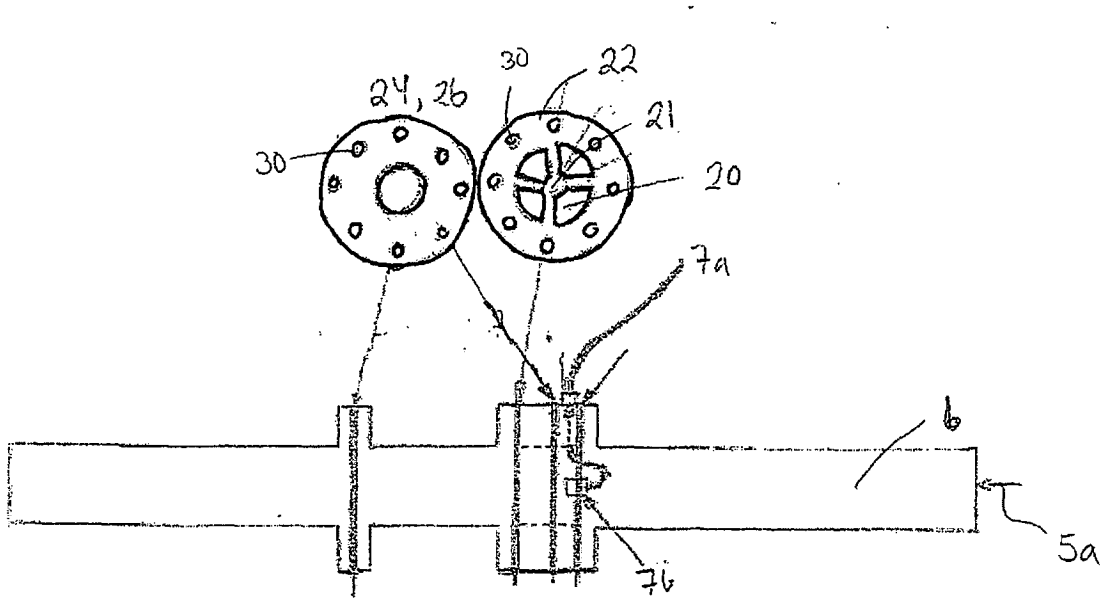

Fig3

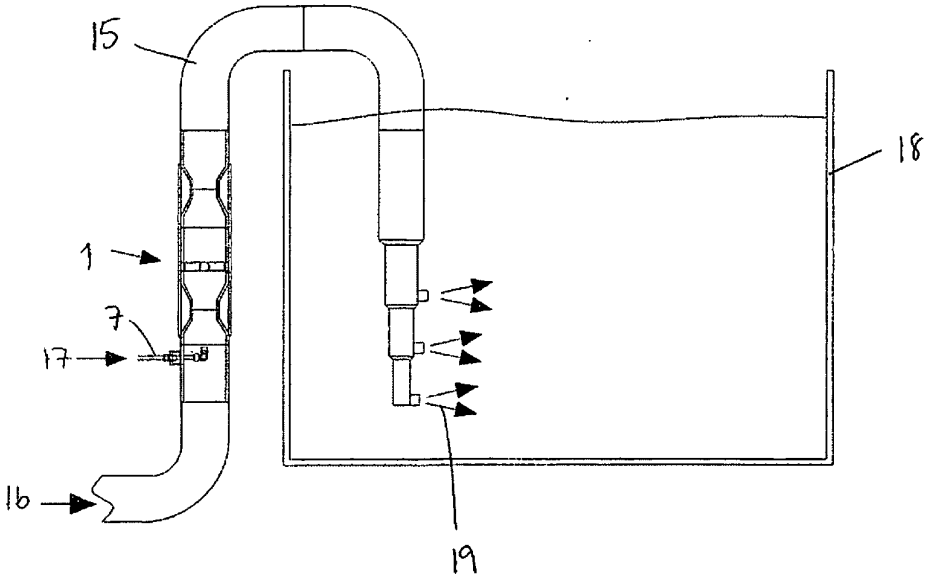

Fig 4

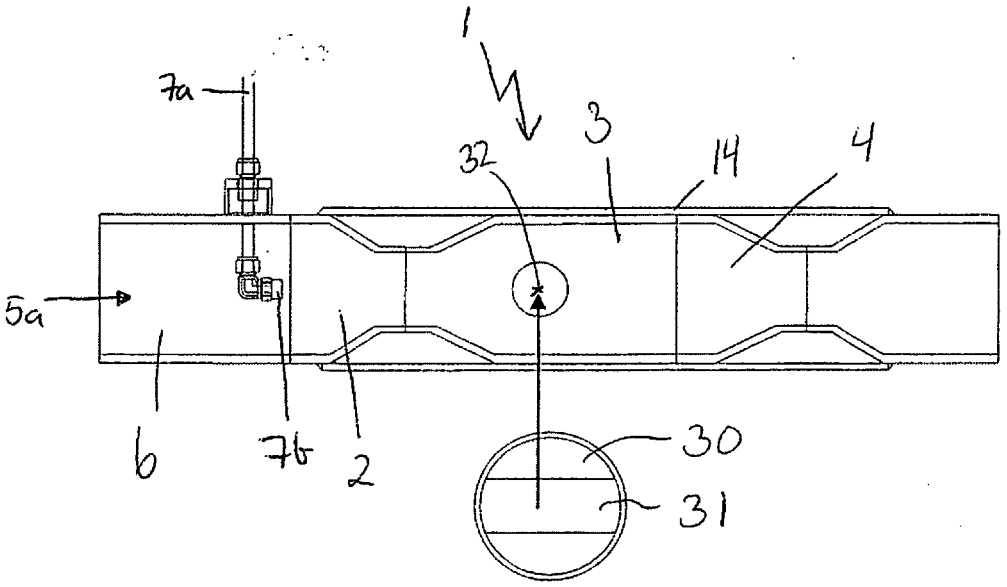

Fig 5

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

- JP 2006326484 B **[0004] [0006] [0020]**
- JP 2006326484 A **[0005]**
- US 6982968 B **[0007] [0008]**
- WO 0136105 A **[0007] [0009]**
- JP 2003117365 B **[0007] [0010]**
- US 20040251566 A **[0011] [0012]**
- US 5810052 A **[0011] [0013]**