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(54) **MIXING**

MISCHEN

MELANGE

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## Description

**[0001]** The invention pertains to the field of process technology and relates to an apparatus and method for mixing a gas with a liquid. The invention can be used, for example, in ore dressing, in dissolving processes, and in the aeration of water.

## BACKGROUND

**[0002]** For the mixing of a gas with a liquid there are used, for example, perforated nozzles through the perforations of which the gas is directed under pressure into the liquid.

**[0003]** Figure 5 in publication GB-1115288 also shows a mixing apparatus in which into a space between two cylindrical surfaces there are fed tangentially a liquid into the upper section and a gas at a lower point, under an annular skirt. The mixture is withdrawn upwards via a connection in the center. In this apparatus, the cross-sectional area of the opening which leads out of the annular mixing space is greater than the area of the feed connections.

## DESCRIPTION OF THE INVENTION

### General description

**[0004]** A mixing apparatus according to Claim 1 has now been invented. Certain preferred embodiments of the invention are stated in the other claims.

**[0005]** The most essential idea of the invention is that the liquid and the gas to be mixed with it are fed tangentially into the space between two surfaces of revolution so that the mixture comes into a rotary motion in the space, and that the mixture leaves the mixing space via an annular nozzle opening the cross-sectional area of which is smaller than the cross-sectional area of the feed connections. During the rotary motion the gas will both become mixed in the form of small bubbles with the liquid and dissolve in the liquid. The pressure in the mixing space is higher than after the nozzle opening, so that after the mixing space the liquid will be supersaturated. In this case, gas will separate from the solution and micro-sized gas bubbles will form.

**[0006]** The nozzle opening is preferably at one end of the mixing space.

**[0007]** There may be even a plurality of feed connections, and they may be placed at desired locations either on the outer or on the inner periphery of the mixing space.

**[0008]** The shape of the reactor may vary, and it is determined according to the use and the application.

**[0009]** The invention can be used, for example, in froth flotation of ores for the forming of bubbles and for the maintaining of a slurry suspension. The invention is highly applicable also to the aeration of waste water tanks and watercourses. Various dissolving processes requiring the adding of a gas are also typical areas of use for the invention.

### Description of the drawings

**[0010]** In the drawings of the specification, Figure 1 shows a top view of a gas-mixing reactor according to the invention, and Figure 2 shows a side view of the same apparatus, in section through A-A, and Figure 3 shows a froth flotation apparatus in which mixing according to the invention is used.

### Detailed description of certain embodiments

**[0011]** The reactor shown in Figures 1 and 2 has a cylindrical outer mantle 1 and, inside it parallelly, a narrower inner mantle 2, which is attached to the closed upper end 3 of the reactor but detached from the reactor bottom 4. Between the mantles there is left an annular chamber 5. There is an opening 6 in the center of the reactor bottom.

**[0012]** The inner mantle 2 has here a cylindrical narrower upper section and a broader cylindrical lower section linked thereto via a conical intermediate section. Thus the cross-sectional area of the upper section of the reactor is greater.

**[0013]** At the upper end of the annular chamber 5 the outer mantle 1 has a feed inlet 7 and in it tangentially a feed pipe 8. A liquid material and a gas to be incorporated into it are fed under pressure via the feed pipe into the annular chamber in such a manner that they come into a rotary motion in the annular chamber. Gas is incorporated, both as bubbles and dissolved, into the liquid. Any gas not mixed with the liquid separates as a ring on the surface of the inner mantle. From this, gas becomes further mixed into the liquid.

**[0014]** At the bottom 4 of the reactor, in its corner, there is an annular limiting ring 9 in such a manner that, between the lower end of the inner mantle 2 and the limiting ring, there is formed an annular nozzle opening 10 having a flow cross section smaller than the cross section of the upstream part of the annular chamber.

**[0015]** The reactor is operated at such a feed pressure that, when the mixture flows to the nozzle opening 10 and its pressure decreases, the mixture is supersaturated with respect to gas, in which case dissolved gas separates out, forming micro-sized bubbles. Such micro-bubbles adhere to the surfaces of larger bubbles in the mixture. These larger bubbles serve as efficient carrier bubbles. Owing to the micro-bubbles the total surface area of the bubbles is very large. The size, number and mutual proportions of the bubbles can be adjusted by adjusting the feed ratio, feeding pressure, or the surface area of the nozzle opening.

**[0016]** The upper end of the inner mantle 2 may also be open, in which case bubbles will leave via that route. Such an apparatus would be especially suited for the processing of a slurry, in which case heavier slurry will

leave via opening 6.

**[0017]** The mineral slurry froth-flotation apparatus according to Figure 3 has a container 11 and, inside it, a gas-mixing reactor 12 of the type described above. Slurry is introduced into the container from the upper end via a feed pipe 13. At the lowest point of the reactor bottom 14 there is connected a recycling pipe 15, through which slurry which has settled on the bottom is directed by means of a pump 16 to the feed pipe 8 of the mixing reactor. Air via connection 17 is also fed into the feed pipe. The overpressure prevailing in the feed pipe is, for example, 1-2 bar. In the reactor, air becomes mixed with the slurry and partly dissolved therein. A large quantity of micro-bubbles are formed in the mixture emerging from the reactor. Hydrophobic mineral particles from the slurry adhere to the surfaces of the bubbles. The bubbles rise to the surface of the container as a froth, which is recovered for further treatment. The process is dimensioned so that the bubbles will have time to separate from the slurry as completely as possible before the slurry flows into the recycling pipe.

## Claims

1. An apparatus for mixing a gas with a liquid, which apparatus has a mixing chamber, at least one feed connection for feeding the gas and the liquid tangentially as a continuous stream into the chamber, and a nozzle opening for withdrawing the mixture as a continuous stream from the mixing chamber, wherein the mixing chamber has a mixing space (5) between two surfaces of revolution one inside the other, into which space the feed connections (8) lead tangentially, **characterized in that** the nozzle opening (10) is annular, the cross-sectional area of the nozzle opening (10) is smaller than the cross-sectional area of the feed connections, and the pressure in the mixing chamber is higher than after the nozzle opening.

2. An apparatus according to Claim 1, **characterized in that** the cross-sectional area of the mixing chamber (5) at a point before the nozzle opening (10) is larger than the cross-sectional area of the nozzle opening.

3. An apparatus according to Claim 1 or 2, **characterized in that** the nozzle opening (10) is at one end of the mixing space (5).

4. A method for mixing a gas with a liquid, in which method the gas and the liquid are fed as a continuous stream via feed connections into a mixing chamber tangentially so that the mixture comes into a rotary motion around the mixing space, the mixing chamber being a mixing space between two surfaces of revolution one inside the other, and the mixture of gas and liquid is withdrawn as a continuous stream from the mixing chamber via a nozzle opening, **characterized in that** the mixture is withdrawn from the mixing space via an annular nozzle opening having a cross-sectional area smaller than the cross sectional area of the feed connections and that the pressure in the mixing space is higher than after the nozzle opening.

5. The use of an apparatus according to any of Claims 1-3 or a method according to Claim 4 in a froth-flotation process or a dissolving process.

## Patentansprüche

1. Vorrichtung zum Mischen eines Gases mit einer Flüssigkeit, welche Vorrichtung eine Mischkammer besitzt, zumindest eine Zufuhrverbindung zur Zufuhr des Gases und der Flüssigkeit tangential als ein kontinuierlicher Strom in die Kammer, und eine Düsenöffnung zum Abzug der Mischung als ein kontinuierlicher Strom aus der Mischkammer, wobei die Mischkammer einen Mischraum (5) zwischen zwei Oberflächen, eine im Inneren der anderen, besitzt, in welchen Raum die Zufuhrverbindungen (8) tangential hineinführen,
**dadurch gekennzeichnet, dass** die Düsenöffnung (10) ringförmig ist und die Querschnittsfläche der Düsenöffnung (10) kleiner als die Querschnittsfläche der Zufuhrverbindungen ist, und der Druck in der Mischkammer höher als nach der Düsenöffnung ist.

2. Vorrichtung gemäß Anspruch 1, **dadurch gekennzeichnet, dass** die Querschnittsfläche der Mischkammer (5) an einem Punkt vor der Düsenöffnung (10) größer ist als die Querschnittsfläche der Düsenöffnung.

3. Vorrichtung gemäß Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** die Düsenöffnung (10) an einem Ende des Mischraumes (5) ist.

4. Verfahren zum Mischen eines Gases mit einer Flüssigkeit, wobei das Gas und die Flüssigkeit als kontinuierlicher Strom über Zufuhrverbindungen tangential in eine Mischkammer eingeführt werden, so dass die Mischung in eine Drehbewegung um den Mischraum herum gerät, wobei die Mischkammer ein Mischraum zwischen zwei Oberflächen ist, von denen eine im Inneren der anderen ist, und die Mischung von Gas und Flüssigkeit als ein kontinuierlicher Strom aus der Mischkammer über eine Düsenöffnung abgezogen wird,
**dadurch gekennzeichnet, dass** die Mischung aus dem Mischraum über eine ringförmige Düsenöffnung abgezogen wird mit einer Querschnittsfläche

kleiner als die Querschnittsfläche der Zufuhrverbindungen, und dass der Druck in der Mischkammer höher als nach der Düsenöffnung ist.

**5.** Verwendung einer Vorrichtung gemäß einem der Ansprüche 1 bis 3 oder eines Verfahrens gemäß Anspruch 4 in einem Schaumflotationsverfahren oder einem Auflösungsverfahren.

**Revendications**

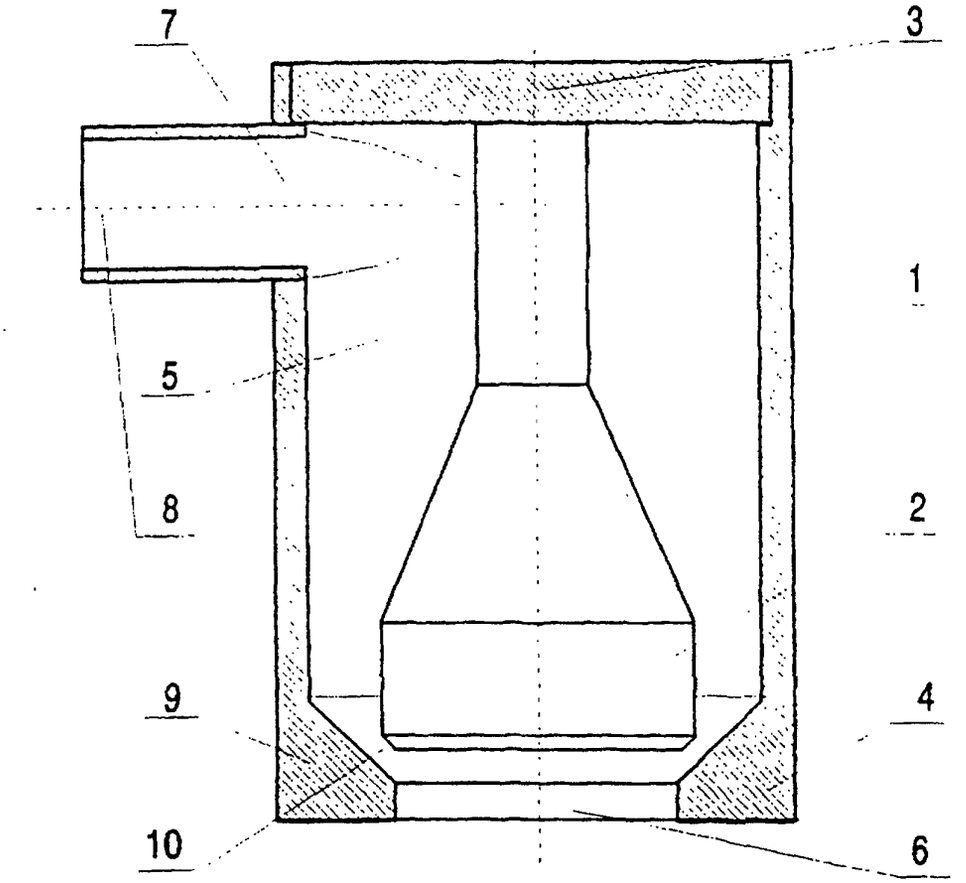
**1.** Dispositif pour mélanger un gaz et un liquide, lequel dispositif a une chambre de mélange, au moins une connexion d'alimentation pour alimenter le gaz et le liquide de manière tangentielle sous la forme d'un flux continu jusque dans la chambre, et une ouverture de buse pour retirer le mélange sous la forme d'un flux continu à partir de la chambre de mélange, la chambre de mélange ayant un espace de mélange (5) situé entre deux surfaces de révolution l'une à l'intérieur de l'autre, espace dans lequel les connexions d'alimentation (8) débouchent de manière tangentielle, **caractérisé en ce que** l'ouverture de buse (10) est annulaire, **en ce que** la surface en coupe transversale de l'ouverture de buse (10) est plus petite que la surface en coupe transversale des connexions d'alimentation, et la pression dans la chambre de mélange est plus élevée qu'après l'ouverture de buse.

**2.** Dispositif selon la revendication 1, **caractérisé en ce que** la surface en coupe transversale de la chambre de mélange (5), en un point situé avant l'ouverture de buse (10), est plus grande que la surface en coupe transversale de l'ouverture de buse.

**3.** Dispositif selon la revendication 1 ou 2, **caractérisé en ce que** l'ouverture de buse (10) est située à une extrémité de l'espace de mélange (5).

**4.** Procédé pour mélanger un gaz et un liquide, procédé dans lequel le gaz et le liquide sont alimentés sous la forme d'un flux continu via des connexions d'alimentation tangentiellement jusque dans une chambre de mélange, de sorte que le mélange vient dans un mouvement rotatif autour de l'espace de mélange, la chambre de mélange étant un espace de mélange situé entre deux surfaces de révolution l'une à l'intérieur de l'autre, et le mélange de gaz et de liquide est retiré sous la forme d'un flux continu à partir de la chambre de mélange via une ouverture de buse, **caractérisé en ce que** le mélange est retiré de l'espace de mélange via une ouverture de buse annulaire ayant une surface en coupe transversale plus petite que la surface en coupe transversale des connexions d'alimentation, et **en ce que** la pression dans l'espace de mélange est plus élevée qu'après l'ouverture de buse.

**5.** Utilisation d'un dispositif selon l'une quelconque des revendications 1 à 3, ou d'un procédé selon la revendication 4, dans un processus de flottation à la mousse ou un processus de dissolution.




A - A

Fig. 2

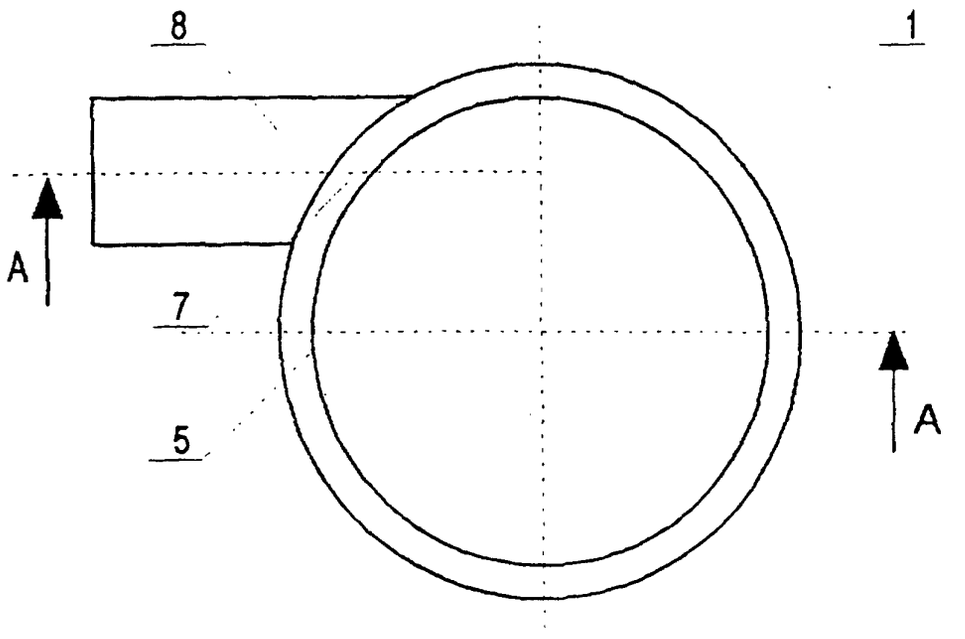



Fig. 1

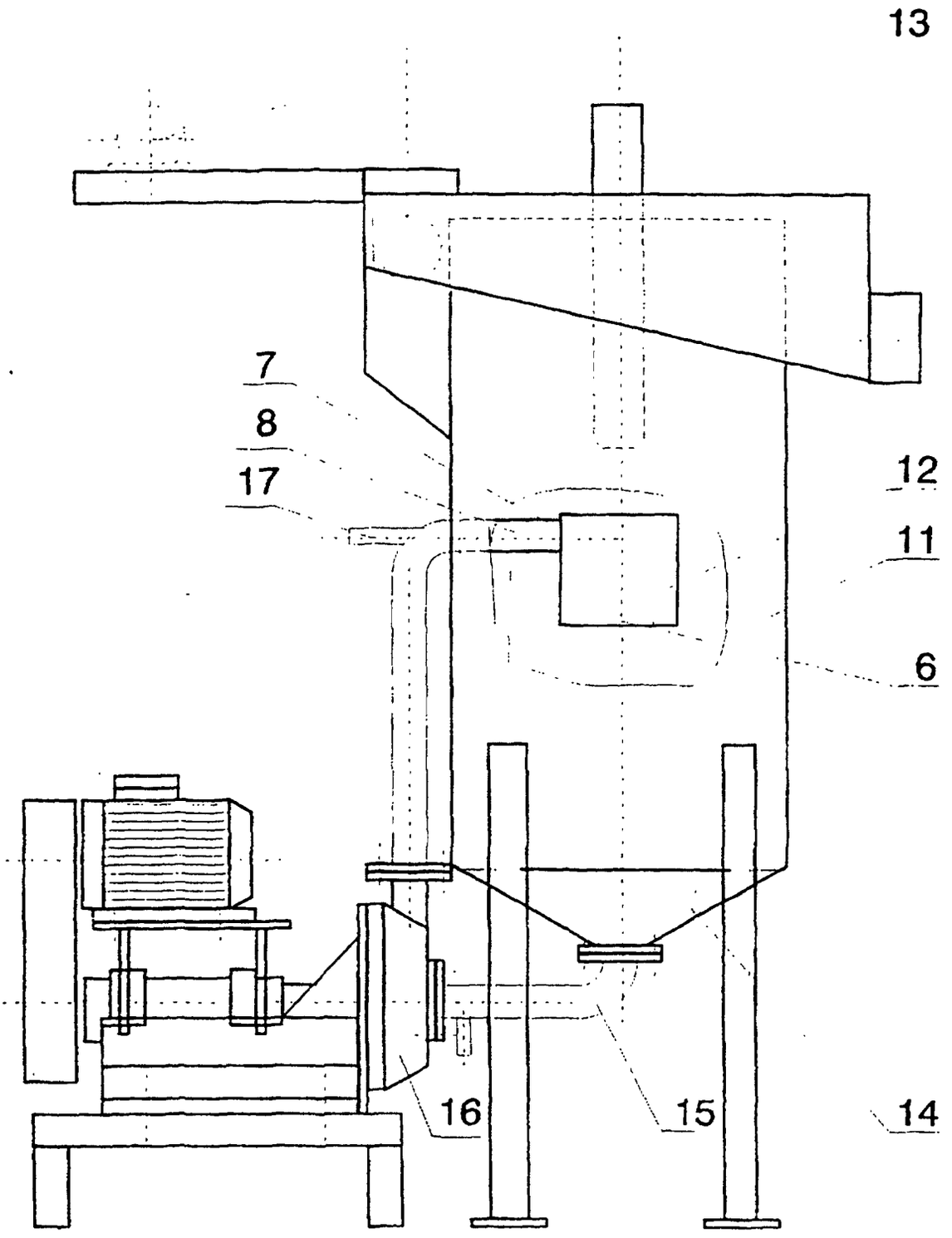



Fig. 3