

United States Patent

Tanaka, deceased et al.

[15] 3,690,621

[45] Sept. 12, 1972

[54] AGITATOR

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[51] Int. Cl.**B01f 5/16**

[58] Field of Search ..259/111, 102, 96, 95; 416/182, 416/184, 185, 186; 261/84, 93, 32; 230/134.48

[56] References Cited

UNITED STATES PATENTS

473,530	4/1892	Smith	259/96
1,413,724	4/1922	Groch.....	259/96
1,084,210	1/1914	Howard.....	259/107
1,571,735	2/1926	Queisser.....	416/185
1,919,970	7/1933	Woods.....	416/184

2,230,146	1/1941	Myers.....	259/9
3,284,055	11/1966	Johansen	259/96 X
3,298,444	1/1967	Haas.....	416/186
3,362,338	1/1968	Stethem.....	416/183
3,387,832	6/1968	Nelson.....	261/93

FOREIGN PATENTS OR APPLICATIONS

1,474,582	2/1967	France.....	259/96
552,573	4/1943	Great Britain.....	259/96

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[57] ABSTRACT

The present disclosure is directed to an agitating apparatus comprising an agitating blade assembly, said agitating blade assembly including upper and lower disk means which are spaced apart by a plurality of radially disposed plate means, said lower disk means also containing a plurality of radially disposed blade plate means attached to its bottom side, and agitating shaft means extending through an opening in the upper disk means and attached to the top side of the lower disk means.

12 Claims, 4 Drawing Figures

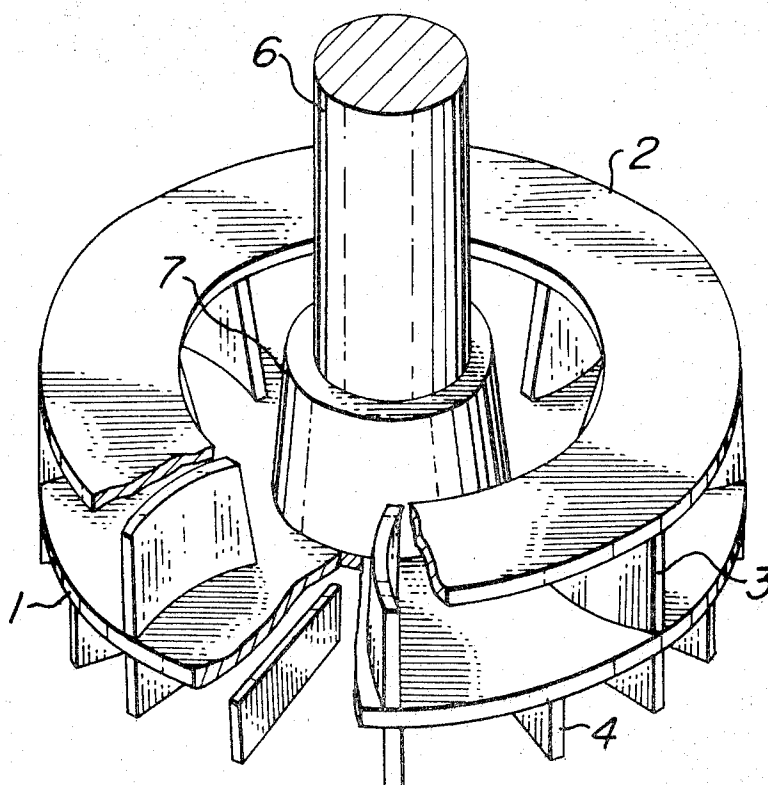


FIG. 1

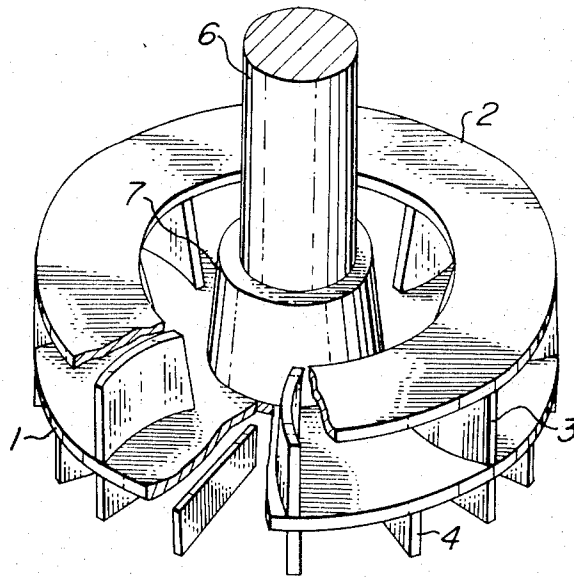
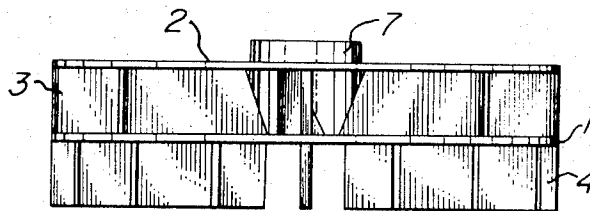


FIG. 2



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FIG. 3

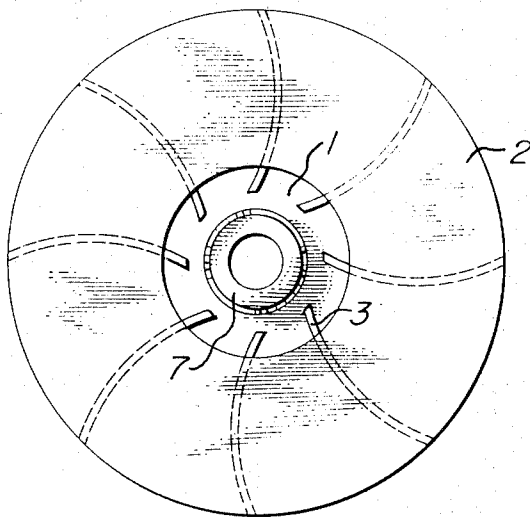
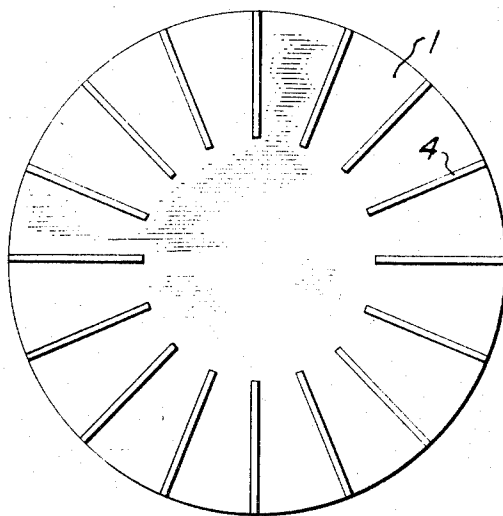


FIG. 4



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The present invention relates to an improved agitating apparatus for promoting gas-liquid contact reaction. More particularly, the present invention is directed to an improved aeration-agitating apparatus comprising disk means provided with a plurality of plate means which cooperate to promote a gas-liquid contact reaction.

A gas-liquid reaction apparatus wherein gas is blown into a liquid phase, or an apparatus used for the submerged culturing of aerobic microorganisms, such as an agitating blade assembly, a turbine having 4 to 6 flat blades, a turbine having curved blades, a disk turbine having bottom blades, and the like, is well known. In these type of apparatus, a gas is blown from the bottom side of said apparatus by means of nozzles or a sparger and the gas bubbles produced thereby are made finer and dispersed by a blade assembly. However, it has been found that these flat blade or curved blade turbines possess many disadvantages including a very large power consumption which is necessary for obtaining a thorough contact of the gas-liquid phase and for obtaining a high rate of gas dissolution.

Although the disk turbine having bottom blades can give a large shearing force to the gas-liquid mixture, and although a high rate of gas dissolution can be obtained with a relatively low power consumption, only a small amount of liquid is discharged by the blade assembly and thus uniform agitation cannot be obtained in the tank. Accordingly, the resulting insufficient mixing makes the yield of reaction product lower.

Generally, an agitating blade assembly for an aeration agitating tank must obtain a high rate of gas dissolution with a corresponding low power consumption and a shortened mixing time while obtaining uniformity or evenness throughout the entire tank. Accordingly, it is desired to provide a blade assembly which will give a high shearing effect to gas bubbles while utilizing as small a power consumption as possible, thereby making said bubbles finer and dispersing them uniformly throughout the entire reaction vessel in a short period of time. Advantageously, the blade assembly should discharge as much as is necessary to establish uniformity throughout the entire reaction vessel and improve the circulating flow in said vessel.

An object of the present invention is to avoid the prior art disadvantages in the agitation of gas-liquid mixtures.

Another object of the present invention is to provide an improved agitating apparatus for promoting gas-liquid contact reactions.

A further object of the present invention is to provide an improved agitating apparatus which utilizes a low power consumption, exhibits uniform agitation in a shorter mixing time and produces an improved yield of reaction product.

A still further object of the present invention is to provide an improved agitating apparatus which gives a high shearing effect to gas bubbles thereby making said bubbles finer and disperses said bubbles uniformly throughout the entire reaction mixture.

Other objects and further scope of applicability of the present invention will become apparent from the detailed description given hereinafter; it should be understood, however, that the detailed description and

specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modification within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

Pursuant to the present invention, it has been found that the above-mentioned disadvantages may be eliminated and a much improved agitating apparatus for promoting gas-liquid contact reactions may be obtained by providing a blade assembly for the agitating apparatus that gives a high shearing effect to gas bubbles with as little a power consumption as possible, and by utilizing said shearing effect to make finer gas bubbles and disperse said bubbles uniformly throughout the entire reaction mixture.

The present invention will become more fully understood from the detailed description give hereinbelow and the accompanying drawings which are given by way of illustration only and thus are not limitative of the present invention and wherein,

FIG. 1 is a perspective view of the agitating apparatus of the present invention;

FIG. 2 is a side view of the agitating blade assembly of the present invention;

FIG. 3 is a top view of the disposition of the curved plates disposed between the upper and lower disk means; and

FIG. 4 is a bottom view of the disposition of the blade plates attached to the bottom of the lower disk means.

Referring now to the drawings wherein like reference numerals are used throughout the various views to designate like parts, the apparatus of the present invention comprises a flat disk 1 provided with a top cover 2, said elements being spaced apart by a plurality of radially extending curved plates 3. The disk means 1 also contains a plurality of radially extending blade plates 4 attached to its bottom side. An agitating shaft 6 extends through an opening in the top cover 2 and is attached to the top side of the flat disk 1 by means of a boss 7.

The flat plates 1 and blade plates 4 are usually called a disk turbine having bottom blades, and are generally used in aeration agitating tanks. A high rate of gas dissolution can be obtained with a small unit power requirement by utilizing the blade assembly according to the present invention. By providing curved blades 3, a large discharging amount can be achieved with very little power consumption, and the mixing time can be shortened. By rotating said agitating blade assembly for aeration agitation, the liquid above the agitating blade assembly is drawn in through a clearance between the top cover 2 and the rotating shaft 6 and discharged by the curved blades 3. Bubbles produced by a gas discharged from nozzles or a sparger provided below the agitating blade assembly are made finer and dispersed by the blade plates 4 and mixed with the liquid discharged by the curved plates 3, and distributed uniformly throughout the entire reaction mixture, whereby the entire reaction mixture of the reaction vessel can be controlled to a uniform dissolved gas concentration.

The blade plates 4 as referred to herein can be flat plates, corrugated plates, curved plates, or the like, depending upon the property of the liquid being agitated.

An agitating blade assembly using flat blade plates 4, as shown in FIGS. 1, 2, 3 and 4, was employed in a 4-kl

tank having a diameter of 1,400 mm. The mixing time and the measured values of power consumed are shown in Tables 1 and 2 at 200 and 300 r.p.m., respectively.

TABLE 1

Mixing time

Identification of blade assembly	Number of revolution	
	200 r.p.m.	300 r.p.m.
Agitating blade assembly for aeration agitation of the present invention	20 sec.	14 sec.
Turbine with 6 flat blades	29 sec.	21 sec.
Turbine with bottom blades	34 sec.	25 sec.

TABLE 2

Consumed power

Identification of blade assembly	Number of revolution	
	200 r.p.m.	300 r.p.m.
Agitating blade assembly for aeration agitation of the present invention	5.1 H.P.	17.0 H.P.
Turbine with 6 flat blades	7.1 H.P.	24.4 H.P.
Turbine with bottom blades	3.9 H.P.	13.0 H.P.

Table 1 shows the situation where 2.3 kl of water was charged into a tank. 900 l per minute of air was introduced into the water and agitation was conducted at 200 r.p.m. and 300 r.p.m., respectively. A pH meter of the immersion type was placed in the tank and while a caustic soda solution was added to the top of said tank, the time required for the pH to become constant was measured. As can be readily noted, the mixing time for the same number of revolutions is shorter when using the agitating blade assembly of the present invention when compared to the flat blade turbines and the bottom-blade disk turbines of the prior art. Table 2 shows the power required for agitation when 900 l per minute of air was introduced into the tank and measured by a strain gage.

According to Tables 1 and 2, a mixing time of 20 seconds can be obtained with 5.1 H.P. when using the agitating main assembly of the present invention, whereas when using a flat blade turbine and a bottom-blade disk turbine, mixing times could not be reduced to 20 seconds, even when using 24 H.P. and 13 H.P., respectively.

Table 3 shows the results of a measurement of the sodium sulfite oxidation rate obtained by operations similar to that shown in Tables 1 and 2.

TABLE 3

Sodium sulfite oxidation rate (Kg-mol/m³.hr.atm.)

Identification of blade assembly	Number of revolution	
	200 r.p.m.	300 r.p.m.
Agitating blade assembly for aeration agitation of	0.600	1.238

the present invention		
Turbine with 6 flat blades	0.333	1.143
Turbine with bottom blades	0.381	0.570

The sodium sulfite oxidation rate is lower but power consumption is higher when using the flat blade turbine rather than the agitating blade assembly of the present invention, when compared at the respective r.p.m. For example, only 0.570 kg-mol/m³.hr.atm. is obtained with a power consumption of 13.0 H.P. in the case of the bottom-blade disk turbine, and thus the power efficiency is not as good as the agitating blade assembly of the present invention.

The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be apparent to one skilled in the art are intended to be included within the scope of the following claims.

What is claimed is:

1. An agitating apparatus comprising an agitating blade assembly, said agitating blade assembly including upper and lower flat horizontal circular disk means which are parallel to one another and which are spaced apart by a plurality of radially extending curved plate means, said upper disk means being provided with a centrally disposed opening, a plurality of radially extending flat blade plate means attached to the bottom side of the lower disk means, the flat blade plate means having horizontal bottom edges which are parallel to said lower disk means, and agitating shaft means extending through the centrally disposed opening and secured to the top side of the lower disk means.

2. An agitating apparatus comprising an agitating blade assembly, said agitating blade assembly including upper and lower circular disk means which are spaced apart by a plurality of radially extending curved plate means, said upper disk means being provided with a centrally disposed opening, a plurality of radially extending flat blade plate means attached to the bottom side of the lower disk means and agitating shaft means extending through the centrally disposed opening and secured to the top side of the lower disk means, wherein the curved plate means extend into the centrally disposed opening.

3. The apparatus of claim 2, wherein the curved plate means are tapered to a point extending from the periphery of the opening into said opening.

4. The apparatus of claim 2, wherein the curved plate means extend from the periphery of the disc means into the centrally disposed opening.

5. The apparatus of claim 2, wherein the flat blade plate means extend inwardly from the periphery of the lower disk means to a position spaced from the center of said disk means.

6. An aeration-agitating apparatus comprising a plurality of radially extending flat blade means attached to the underside of a lower flat horizontal circular disk means, said flat blade means having lower horizontal edges which are parallel to said lower disk means, a plurality of substantially radially extending curved blade means attached at their bottoms to the upper side of said lower disk means, an upper flat horizontal circular disk means attached at the bottom side thereof to the tops of said curved blade means, and connecting

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means for connecting at least one of said disk means to rotating means.

7. An apparatus according to claim 6, characterized in that said upper disk means is provided with a centrally disposed opening and in that said connecting means includes an agitating shaft means extending through the centrally disposed opening and attached to the upper side of said lower disk means.

8. An apparatus according to claim 7, characterized in that said agitating shaft means is attached to the upper side of said lower disk means by way of an annular cylindrical boss, said boss being integral with said lower disk means.

9. An apparatus according to claim 6, characterized in that said upper disk means is substantially smooth over the entire surface of the upper side thereof up to the edges of said opening, said opening being formed as a bore through said upper disk means, the edges of said bore intersecting with the surface of the upper side of said upper disk means such that said bore is open to the surrounding medium in all directions above said upper disk means.

10. An apparatus according to claim 6, characterized in that both said flat blade means and said curved blade

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means extend substantially perpendicularly with respect to the surfaces of the respective disk means.

11. An aeration-agitating apparatus comprising a plurality of radially extending flat blade means attached to the underside of a lower circular disk means, a plurality of substantially radially extending curved blade means attached at their bottoms to the upper side of said lower disk means, an upper circular disk means attached at the bottom side thereof to the tops of said curved blade means, and connecting means for connecting at least one of said disk means to rotating means, said upper disk means being provided with a centrally disposed circular opening, each of said curved blade means tapering downwardly from the edge of said upper disk means which delimits the opening to respective points located on the lower disk means radially inwardly from said edge.

12. An apparatus according to claim 1, characterized in that said opening is formed as a bore through said upper disk means, the edges of said bore intersecting with the flat upper surface of said upper disk means such that said bore is open to the surrounding medium in all directions above said upper disk means.

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