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(54) A process for dispersing one fluid in another.

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(73) Proprietor: UNION CARBIDE CORPORATION
39 Old Ridgebury Road
Danbury Connecticut 06817 (US)

(72) Inventor: Litz, Lawrence Marvin
16 Briarwood Lane
Pleasantville N.Y. 10570 (US)
Inventor: Santalone, John Joseph, Jr.
15 Prospect Avenue
Valhalla N.Y. 10595 (US)

(74) Representative: Schwan, Gerhard, Dipl.-Ing.
Elfenstrasse 32
D-8000 München 83 (DE)

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Description

Technical Field

This invention relates to a process for dispersing a fluid, which may be a gas or liquid, into a high viscosity liquid.

Background Art

In certain types of systems involving the reaction and/or blending of a material or fluid of relatively high viscosity with a second fluid, it is desirable to uniformly disperse the second fluid throughout the mass of high viscosity material. Such a system is the bleaching of medium consistency pulp with gaseous oxygen or with aqueous solutions of chlorine dioxide, hydrogen peroxide, or sodium hypochlorite. The bleaching is intended to whiten and brighten the pulp without damaging the strength characteristics of the paper to be made from the pulp. The main light absorbing substances in wood pulp are the lignin and resin components. Therefore, to make the pulp whiter, these substances must be removed. Oxidation, reduction, or hydrolysis make the lignin and resin components soluble so that they can be washed away by aqueous solutions. The initial solubilization of the bulk of the lignin is carried out with non-oxidizing substances such as alkalies, sulfides, or sulfites; however, continuation of the dissolution by this means is found to seriously degrade the carbohydrate fraction of the pulp, affecting both strength and yield. Since lignin is readily oxidized by many substances, the remainder, then, is removed by oxidation and dissolution of the oxidized products in water and aqueous alkali. Chlorine, chlorine dioxide, hypochlorite, hydrogen peroxide, ozone, and oxygen can be used separately or in various combinations as oxidizing agents.

Pulp bleaching plants generally treat the pulp in a continuous flow mode with a series of oxidizing agents. An alkaline treatment step is often provided between some of the oxidizing treatment steps with a water wash after each step. A typical sequence would be to start with an aqueous chlorine treatment, then a water wash, an alkaline treatment, water wash, aqueous chlorine dioxide treatment, and a final water wash. The apparatus in which these steps are conventionally carried out are, in order of use, a chlorination tower, a water washer, a steam mixer, a thick stock pump, an upflow or downflow extraction tower, a water washer, a chlorine dioxide mixer, a chlorine dioxide tower, and a water washer.

It has been known for some time that the addition of about five kilograms of oxygen gas per metric ton of dry pulp to the process between the aqueous chlorine treatment step and the alkaline treatment step permits equivalent levels of bleaching to be obtained at reduced chlorine dioxide (or other oxidant) requirements. The relatively high viscosity of the pump makes it difficult to disperse the oxygen gas uniformly throughout the pulp. The reason for the difficulty lies in the fact that it is necessary to create turbulence in the viscous material in order to obtain a good dispersion, and early mixing techniques were just not up to this task.

Typically, the pulp entering the alkaline extraction tower is of medium consistency, containing about ten to about fifteen percent by weight of dry pulp admixed with an alkaline aqueous solution. Its flow characteristics, or viscosity, are comparable to that of ground meat or damp papier-mache. If the oxygen gas is not well dispersed within the pulp mass, it will not be able to reach most of the pulp and the desired reaction will not be able to take place in the portion of the pulp mass unexposed to the oxygen.

The first commercial plants using oxygen with medium consistency pulp achieved adequate dispersion of the oxygen gas in the pulp by employing dynamic mechanical mixers. Such mixers, however, are complicated pieces of equipment with high capital, maintenance, and operational costs.

A process for dispersing a gas in a liquid or liquid-solids mixture having a relatively higher viscosity, comprising the steps of:

(a) providing a confined zone having an opening at its upstream end, an opening at its downstream end, and a hypothetical central axis running from its upstream end to its downstream end;

(b) introducing the liquid or liquid-solids mixture into the confined zone at the opening in its upstream end in such a manner that it passes from the opening in the upstream end through the opening in the downstream end;

(c) dividing the gas into a plurality of streams by passing said gas into porous pipes positioned in the confined zone, and introducing the streams into the liquid or liquid-solids mixture cocurrently therewith; is known from GB—A—2 095 123. The pipes are arranged in one or more rows, one behind the other and below the other, so as to form gasifying surfaces parallel with the liquid stream. In a similar process known from GB—A—2 015 360 the first fluid, e.g. a gas, for being dispersed in the second fluid, e.g. a pulp, is divided into a plurality of streams by passing the first fluid through a single perforated tube positioned in the confined zone. Furthermore it is known from FR—A—2 286 694 to disperse by such a process a liquid having a low viscosity in a material of high viscosity, e.g. molten thermoplastic material, wherein the liquid of low viscosity is passed through a plurality of rows parallel, juxtapositioned porous or perforated tubes, wherein adjacent rows of tubes extend in directions normal to each other.

Disclosure of the Invention

An object of the invention is to provide a process which will disperse one fluid uniformly throughout another fluid where one of the fluids characteristically has a relatively high viscosity thus achieving an otherwise difficult to attain level of dispersion without mechanical mixing devices.

Other objects and advantages will become apparent hereinafter.

According to the present invention, a process for dispersing a first fluid in a second fluid having a relatively higher viscosity, comprising the following steps:

(a) providing a confined zone having an opening at its upstream end, an opening at its downstream end, and a hypothetical central axis running from its upstream end to its downstream end;

(b) introducing the second fluid into the confined zone at the opening in its upstream end in such a manner that the second fluid passes from the opening in the upstream end through the opening in the downstream end;

(c) dividing the first fluid into a plurality of streams by passing said first fluid into a series of perforated or porous pipes positioned in the confined zone, and introducing the streams into the second fluid co-currently therewith, is characterized in that the first fluid is divided into about 269 to about 10 764 streams per m^2 (about 25 to 1000 streams per square foot) of a cross-section of the confined zone perpendicular to said central axis by being passed into a series of 2 to 6 sets of said pipes, with the sets of pipes being about equally spaced apart from each other by about 25 to about 305 mm (about 1 to about 12 inches), with the pipes in each set being spaced apart from the other pipes in the set, across the cross-section of the confined zone in which said set is positioned, by about 25 to about 254 mm (about 1 to 10 inches), and with the pipes in each set being in a staggered relationship to the pipes in other sets, said streams being about equidistant from one another, the distance between the streams being about 9.7 to about 64.5 mm (about 0.375 to about 2.5 inches).

Brief Description of the Drawing

Figure 1 is a schematic diagram of a view of a cross-section taken from the upstream or downstream end of one embodiment of the invention.

Figure 2 is a side view cross-section of the same embodiment seen in Figure 1.

Figure 3 is a schematic diagram of one of the small pipes shown in Figure 1 taken from the downstream end and showing two rows of outlet ports. The small pipe has been enlarged over its counterpart in Figure 1.

Figure 4 is a schematic diagram of an enlarged section of Figure 3 showing some of the outlet ports.

Figure 5 is a schematic diagram of a plan view cross-section of Figure 4 showing detail of the outlet ports.

Detailed Description

While the invention will be described in terms of an important application, i.e., pulp bleaching, it has application in many other industrial processes such as dispersing dyes in high viscosity polymers; dispersing additives in high viscosity food materials; and blending epoxy components, and other processes where dispersion of one material in another is considered to be a critical factor. Liquid/liquid and gas/liquid mixtures are contemplated, the fluid having the relatively higher viscosity, of course, being a liquid or semi-liquid. The liquid to be dispersed can also have a relatively high viscosity provided that it is capable of being passed through the second confined zones and the ports.

The process provides a series of steps whereby a plurality of small streams is introduced across the flow of a high viscosity fluid, the flow pattern being achieved with minimal pressure drop. The number of streams is in the range of about 269 streams per m^2 (about 25 streams per square foot) of cross-section of the confined zone to about 10764 streams per m^2 (about 1000 streams per square foot) of the cross-section. The cross-section used here is a cross-section perpendicular to the hypothetical central axis referred to above. The cross-section is selected at any point in the confined zone at which all of the streams have been formed. This is usually between the midpoint of the axis and the downstream end of the zone, preferably closer to the midpoint. The preferred number of streams is in the range of about 538 to about 6458 per m^2 (about 50 to about 600 streams per square foot). The streams are about equidistant from one another, the distance between streams being about 9.7 to about 64 mm (about 0.375 to about 2.5 inches) and preferably about 12.9 to about 43.9 mm (about 0.5 to about 1.7 inches). The direction of flow of these small streams of liquid or gas bubbles is defined by the flow of the relatively higher viscosity fluid. The dispersion can be enhanced with the use of a mixing device such as a static mixer located downstream of the apparatus used to carry out subject process.

A typical static mixer has a multiplicty of baffles located in a pipe. The baffles sequentially subdivide and mix material flowing through the pipe. The utilization of subject process upstream of the static mixer permits a reduction in the number of baffles (or mixing elements) in the static mixer.

It is advantageous that the apparatus, which can be used to carry out the process of this invention is low in capital cost, low in maintenance expense, and requires minimum modifications to existing plant equipment. In addition to these advantages, the process itself is one in which medium consistency pulp can be profitably treated (i) with oxygen prior to the first alkaline bleach stage or (ii) with other bleach chemicals such as chlorine dioxide, hypochlorite, or hydrogen peroxide in aqueous solutions, both resulting in a reduction in the overall cost of bleach chemicals.

A preferred apparatus utilizes a series of relatively small diameter perforated or porous pipes within a relatively larger diameter pipe. The larger diameter pipe is referred to as the confined zone. The pipes are made of conventional materials such as stainless steel. In a typical pulp bleaching system employing oxygen in an oxidative extraction, the large pipe is placed between the thick stock pump and the first alkaline extraction tower. The main stream of pulp or pulp mass flowing through the large pipe comprises a mixture of about 10 to about 15 parts by weight pulp solids with, the balance, a solution of water and alkali, usually dilute. This is considered a medium consistency pulp. A plurality of uniform continuous or discontinuous streams of oxygen flow in a downstream direction from the perforations or pores of the small diameter pipes. The flow rate of the pulp mass stream is about 150 to about 100 metric tons of pulp solids per day. The flow rate of the oxygen is about 22.6 to 156 standard m^3/h (about 800 standard cubic feet per hour (scfh) to about 5500 scfh).

The small pipes are considered to be arranged in sets and there are several of these sets in the large pipe. Spacing between the small pipes in a set and between the sets themselves is balanced so that bridging is avoided without sacrificing uniformity of dispersion. The diameter and placement of the small pipes are also a factor affecting bridging. Bridging is caused by, for example, the accumulation of a highly viscous fibrous material in the path of flow, eventually blocking it. It is of especial concern with medium consistency pulp because the pulp begins to lose water as the bridge forms causing the bridging pulp to become increasingly more rigid. The rate at which the bridge forms and the amount of bridge formation are a function of the nature of the fibrous mass such as fiber length, the kind of fiber, prior treatment of the fiber, and the lubricating properties of the first fluid.

The small pipes in each set are about equally spaced from one another and about 25 to about 254 mm (about 1 to about 10 inches) apart, preferably about 76 to about 127 mm (about 3 to about 5 inches) apart. The sets of pipes are spaced apart from one another by about 25 to about 305 mm (about 1 to about 12 inches), preferably about 76 to about 152 mm (about 3 to about 6 inches). It is also preferred that the pipes in each set are in a staggered relationship to the pipes in the other sets. In this case, if one were to take an upstream/downstream cross-section through one of the small pipes in a three set system, there would only be one pipe in the cross-section.

There are about 2 to about 6 sets provided in the confined zone and preferably about 3 to about 5 sets and there are about 3 to about 8 small pipes per set, about 2 to about 6 small pipes per set being preferred.

Referring to the Drawing

In Figures 1 and 2, pipe 21 encloses the confined zone. It is supported by flanges 22 and 23. Various braces and welds (not shown) also provide support for the structure. Annular chamber 24 is formed by ring 25 and closure rings 26. It has an inlet pipe 27 and an outlet valve 28. Small pipes 1, 4, 7, 10, 13, and 16 represent the first set of small pipes; small pipes 2, 5, 8, 11, and 14 represent the second set; and small pipes 3, 6, 9, 12, and 15, the third set. Hypothetical axis 29 of pipe 21 runs from the upstream end to the downstream end. Small pipes 1, 2, and 3 as well as the other small pipes are perpendicular to hypothetical axis 29. The small pipes may also be inclined insofar as hypothetical axis 29 is concerned, the angle of inclination lying in the range of about 20° to about 90°. It is preferred that the angle be the same for all small pipes. Further, each set lies in its own plane and each plane bears a spaced relationship to each other plane. While a plane is usually described as two dimensional, i.e., without height or depth, in this context it is considered to have a height or depth equal to the diameter of the zones or pipes of the set which lie in the plane. The plane bears the same angle of inclination as the pipes in the set, which lies in that plane. Both ends of each small pipe are open. These ends are referred to as inlet ports 30.

Figure 3 is an enlargement of one of the small pipes 2 through 15 showing outlet ports 31 in a staggered array. The small pipe has a hypothetical axis 32 which, of course, would be perpendicular to hypothetical axis 29 if shown in Figure 2.

Figure 4 is an enlargement of a section of the small pipe shown in Figure 3.

Figure 5 is a cross-section of the small pipes shown in Figures 3 and 4. Axes 33 of outlet ports 31 are at a ninety degree angle to each other, and perpendicular to hypothetical axis 32.

The angle is more particularly defined as follows: the central axis of each outlet port is at an angle of about 0° to about 90°, and preferably about 45°, from a hypothetical line 34 running downstream from the point at which the central axis of the outlet port meets the central axis of the small pipe, said hypothetical line being perpendicular to the central axis of the small pipe, parallel to the central axis of the confined zone, and lying in the same plane as the central axis of the outlet port.

The following example illustrates the invention:

Example

Subject process is carried out in the apparatus described above. The apparatus is located in a softwood, kraft pulp bleach plant using a conventional bleaching process. The normal flow rate through the apparatus is 350 metric tons per day of pulp solids (or pulp mass on an air dried basis). Pulp mass from the washer following the chlorine stage is made alkaline and is heated prior to being pumped into the bottom of a standard upflow alkaline extraction reaction tower. The initial pulp mass is a mixture of 11 percent pulp solids and 89 percent water. The apparatus is inserted into a 610 mm (24 inch) diameter pipe line, which carries the pulp mass into the bottom of the upflow tower. Pipe 21 is 591 mm (23.25 inches) in inner diameter and is 457 mm (18 inches) long. There are sixteen small pipes, placed as shown in the drawing, equidistant from adjacent pipes. There are three sets of small pipes, the sets being spaced 102 mm (four inches) apart. The small pipes are 7.6 mm (0.30 inch) in inner diameter and 13.7 mm (0.54 inch) in outer diameter. They are Schedule 80 pipes made of AISI 304 stainless steel. Small pipes 1 and 16 have one row of outlet ports 31 and small pipes 2 thorugh 15 have two rows of outlet ports 31. Each row of outlet ports 31 is centered on its small pipe, e.g. where the small pipe is 267 mm (10.5 inches) long, the row is only about 165 mm (6.5 inches) long and 51 mm (two inches) at either end of the pipe have no outlet ports. The lengths of each, i.e., pipe and row, are as follows:

small pipe no.	mm	length of small pipe (inches)	mm	approximate length of row (inches)
1 and 16	267	10.5	165	6.5
2 and 15	394	15.5	279	11.0
3 and 14	483	19.0	381	15.0
4 and 13	533	21.0	457	18.0
5 and 12	584	23.0	508	20.0
6 and 11	610	24.0	533	21.0
7 and 10	635	25.0	559	22.0
8 and 9	635	25.0	559	22.0

Outlet ports 31 have inner diameters of 0.64 mm (0.025 inch) and are 76 mm (three inches) apart from adjacent outlet ports 31 in the same row. Thus, if all of the outlet ports 31 in each of small pipes 2 to 15 were in the same row, they would be 38.1 mm (1.5 inches) apart. The axes of outlet ports 31 are at the angles shown in Figure 5, the axes of outlet ports 31 in small pipes 1 and 16 being directed to the interior of pipe 21. The number of streams is 689 per m^2 (64 per square foot) of cross-section.

Oxygen at a pressure of about 929 kPa (120 psig) is introduced through inlet pipe 27 25.4 mm (one inch) internal diameter, Schedule 40) into annular chamber 24. It then passes into the small pipes through inlet ports 30 and out through outlet ports 31 into pipe 21 (wall 9.5 mm (0.375 inch) thick). The amount of oxygen introduced is 4 kilograms per metric ton of pulp solids.

It is found that the quantity of bleach chemicals required to achieve the plant's target brightness of 90 Elephro is substantially reduced, e.g., a reduction of 18 percent in chlorine dioxide and of 8 percent in chlorine is found.

Claims

1. A process for dispersing a first fluid in a second fluid having a relatively higher viscosity, comprising the following steps:

(a) providing a confined zone having an opening at its upstream end, an opening at its downstream end, and a hypothetical central axis (29) running from its upstream end to its downstream end;

(b) introducing the second fluid into the confined zone at the opening in its upstream end in such a manner that the second fluid passes from the opening in the upstream end through the opening in the downstream end;

(c) dividing the first fluid into a plurality of streams by passing said first fluid into a series of perforated or porous pipes (1 to 16) positioned in the confined zone, and introducing the streams into the second fluid cocurrently therewith; characterized in that the first fluid is divided into about 269 to about 10 764 streams per m^2 (about 25 to 1000 streams per square foot) of a cross-section of the confined zone perpendicular to said central axis (29) by being passed into a series of 2 to 6 sets (1, 4, 7, 10, 13, 16; 2, 5, 8, 11, 14; 3, 6, 9, 12, 15) of said pipes (1 to 16), with the sets of pipes being about equally spaced apart from each other by about 25 to about 305 mm (about 1 to about 12 inches), with the pipes in each set being spaced apart from the other pipes in the set, across the cross-section of the confined zone in which said set is positioned, by about 25 to about 254 mm (about 1 to 10 inches), and with the pipes in each set being in a staggered relationship to the pipes in other sets, said streams being about equidistant from one another, the distance between the streams being about 9.7 to about 64.5 mm (about 0.375 to about 2.5 inches).

2. The process defined in claim 1 wherein the number of streams is in the range of about 538 to about 6458 per m^2 (about 50 to about 600 per square foot) of cross-section.

3. The process defined in claim 2 wherein the distance between the streams is about 12.9 to about 43.9 mm (about 0.5 to about 1.7 inches).

4. The process defined in claim 1 wherein the second fluid is a pulp mass comprising a mixture of about 10 to about 15 percent by weight pulp solids and, the balance, an alkaline solution.

5. The process defined in claim 4 wherein the first fluid is oxygen, said oxygen being introduced into the pulp mass in an amount of about 2.5 to about 7.5 kilograms of oxygen per metric ton of pulp solids.

6. The process defined in claim 1 wherein the first fluid/second fluid dispersion is mixed downstream of the confined zone.

7. The process defined in claim 6 wherein the mixing is performed with a static mixer.

Patentansprüche

1. Verfahren zum Dispergieren eines ersten Fluids in einem zweiten Fluid, das eine relativ höhere Viskosität hat, mit den folgenden Verfahrensschritten:

(a) Vorsehen einer begrenzten Zone, die eine Öffnung an ihrem stromaufwärtigen Ende, eine Öffnung an ihrem stromabwärtigen Ende und eine gedachte Mittelachse (29) aufweist, die von dem stromaufwärtigen zu dem stromabwärtigen Ende verläuft;

(b) Einleiten des zweiten Fluids in die begrenzte Zone an der Öffnung in dem stromaufwärtigen Ende derart, daß das zweite Fluid von der Öffnung in dem stromaufwärtigen Ende durch die Öffnung in dem stromabwärtigen Ende strömt;

(c) Unterteilen des ersten Fluids in eine Mehrzahl von Strömen, indem das erste Fluid in eine Reihe von perforierten oder porösen Rohren (1 bis 16) geleitet wird, die in der begrenzten Zone angeordnet sind, und Einleiten der Ströme in daz zweite Fluid im Gleichstrom mit diesem;

dadurch gekennzeichnet, daß das erste Fluid in etwa 269 bis etwa 10 764 Ströme je m^2 (etwa 25 bis 1000 Ströme je Quadratfuß) einer zu der Mittelachse (29) senkrechten Querschnittsfläche der begrenzten Zone unterteilt wird, indem es in eine Reihe von 2 bis 6 Gruppen (1, 4, 7, 10, 13, 16; 2, 5, 8, 11, 14; 3, 6, 9, 12, 15) der Rohre (1 bis 16) eingeleitet wird, wobei die Gruppen der Rohre einen näherungsweise gleichen gegenseitigen Abstand von etwa 25 bis etwa 305 mm (etwa 1 bis etwa 12 Zoll) haben, die Rohre innerhalb jeder Gruppe quer zu dem Querschnitt der begrenzten Zone, innerhalb dessen die Gruppe angeordnet ist, einen Abstand von etwa 25 bis etwa 254 mm (etwa 1 bis 10 Zoll) haben und die Rohre in jeder Gruppe versetzt zu den Rohren in den anderen Gruppe angeordnet sind, und wobei die Ströme einen näherungsweise gleichen gegenseitigen Abstand von etwa 9,7 bis etwa 64,5 mm (etwa 0,375 bis etwa 2,5 Zoll) haben.

2. Verfahren nach Anspruch 1, wobei die Anzahl der Ströme im Bereich von etwa 538 bis etwa 6458 je m^2 (etwa 50 bis etwa 600 je Quadratfuß) der Querschnittsfläche liegt.

3. Verfahren nach Anspruch 2, wobei der Abstand zwischen den Strömen etwa 12,9 bis etwa 43,9 mm (etwa 0,5 bis etwa 1,7 Zoll) beträgt.

4. Verfahren nach Anspruch 1, wobei das zweite Fluid eine Pulpenmasse in Form eines Gemisches von etwa 10 bis etwa 15 Gewichtsprozent Pulpenfeststoffen und einer alkalinen Lösung als Rest ist.

5. Verfahren nach Anspruch 4, wobei das erste Fluid Sauerstoff ist, der in die Pulpenmasse in einer Menge von etwa 2,5 bis etwa 7,5 Kilogramm Sauerstoff je metrische Tonne an Pulpenfeststoffen eingeleitet wird.

6. Verfahren nach Anspruch 1, wobei die Dispersion aus erstem Fluid und zweiten Fluid stromabwärts von der begrenzten Zone vermischt wird.

7. Verfahren nach Anspruch 6, wobei das Mischen mit einem statischen Mischer erfolgt.

Revendications

1. Procédé pour disperser un premier fluide dans un seconde fluide ayant une viscosité relativement plus forte, comprenant les étapes suivantes:

(a) production d'une zone confinée comprenant un orifice à son extrémité amont, un orifice à son extrémité aval et un axe central hypothétique (29) allant de son extrémité amont à son extrémité aval;

(b) introduction du second fluide dans la zone confinée au niveau de l'orifice à son extrémité amont de telle manière que le seconde fluide passe depuis l'orifice présent dans l'extrémité amont à travers l'orifice présent dans l'extrémité aval;

(c) division du premier fluide en plusieurs courants par passage dudit premier fluide dans une série de conduits perforés ou poreux (1 à 16) positionnés dans la zone confinée, et introduction des courants dans le seconde fluide à co-courant avec ce second fluide;

caractérisé en ce que le premier fluide est divisé en un nombre d'environ 269 à environ 10 764 courants par m^2 (environ 25 à 1000 courants par ft^2) d'une section transversale de la zone confinée perpendiculaire audit axe central (29) par passage dans une série de 2 à 6 jeux (1, 4, 7, 10, 13, 16; 2, 5, 8, 11, 14; 3, 6, 9, 12, 15) desdits conduits (1 à 16), les jeux de conduits étant espacés les uns des autres par des distances approximativement égales, d'environ 25 à environ 305 mm (environ 1 à environ 12 inches), les conduits dans chaque jeu étant distants des autres conduits dans le jeu, à travers la section transversale de la zone confinée dans laquelle ledit jeu est positionnée, d'environ 25 à environ 254 mm (environ 1 à 10 inches), et les conduits dans chaque jeu étant décalés par rapport aux conduits dans les autres jeux, lesdits courants étant approximativement équidistants les uns des autres, la distance entre les courants étant d'environ 9,7 à environ 64,5 mm (environ 0,375 à environ 2,5 inches).

2. Procédé suivant la revendication 1, dans lequel le nombre de courants est compris dans l'intervalle

d'environ 538 à environ 6458 par m^2 (environ 50 à environ 600 par ft^2) de section transversale.

3. Procédé suivant la revendication 2, dans lequel la distance entre les courants est d'environ 12,9 à environ 43,9 mm (environ 0,5 à environ 1,7 inch).

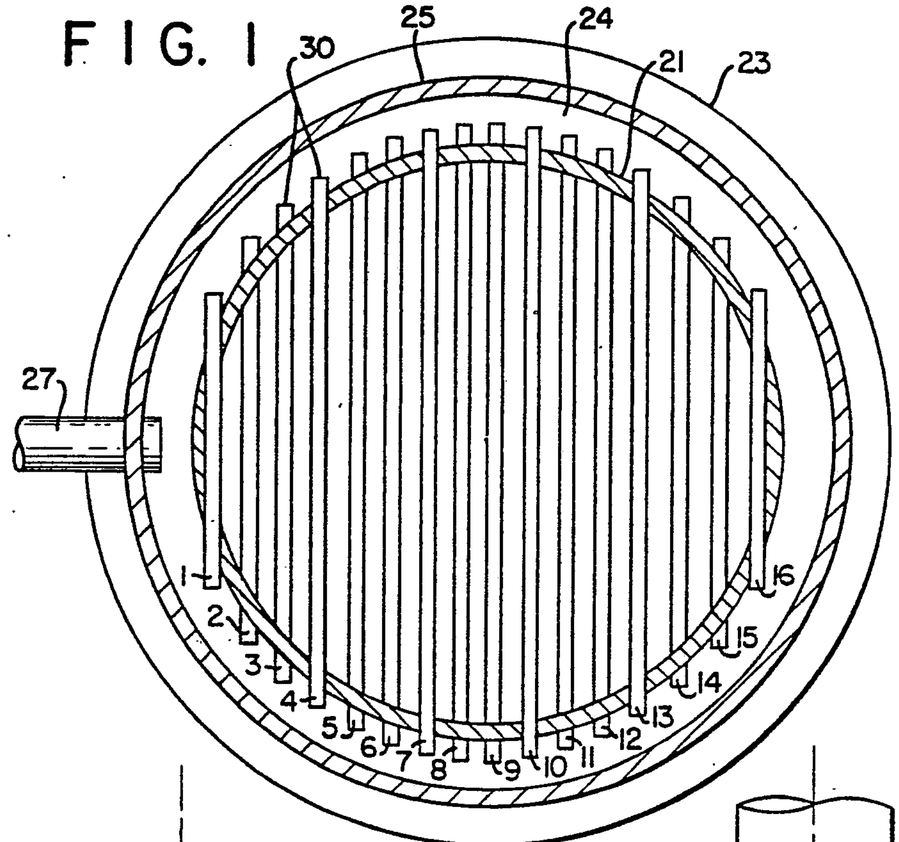
4. Procédé suivant la revendication 1, dans lequel le second fluide est une masse de pâte à papier comprenant un mélange d'environ 10 à environ 15 pour cent en poids de matières solides de la pâte à papier, le reste étant constitué d'une solution alcaline.

5. Procédé suivant la revendication 4, dans lequel le premier fluide est l'oxygène, cet oxygène étant introduit dans la masse de pâte à papier en une quantité d'environ 2,5 à environ 7,5 kilogrammes d'oxygène par tonne de matières solides de la pâte à papier.

6. Procédé suivant la revendication 1, dans lequel la dispersion premier fluide/second fluide est mélangée en aval de la zone confinée.

7. Procédé suivant la revendication 6, dans lequel le mélange est effectué au moyen d'un mélangeur statique.

FIG. 1



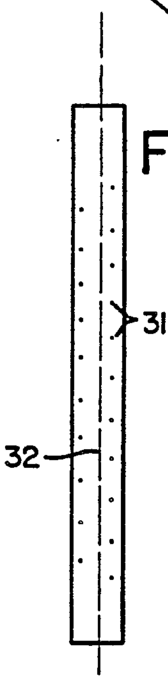


FIG. 3

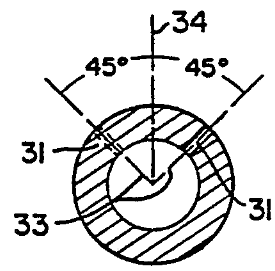


FIG. 5

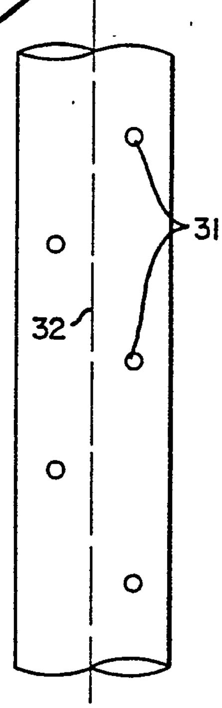


FIG. 4

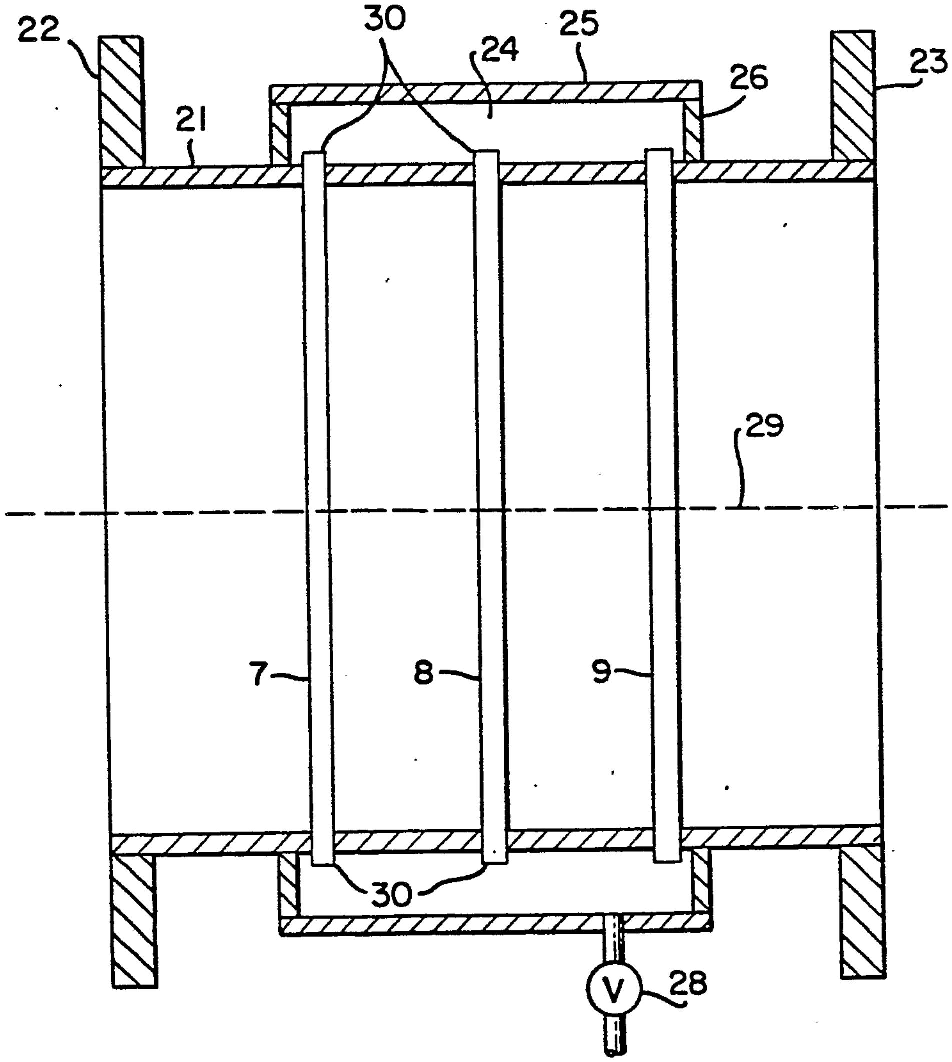


FIG. 2