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⑳ **METHOD AND APPARATUS FOR MIXING PULP WITH GASES.**

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US-A-4 093 506</p> | <p>㉕ Proprietor: WEYERHAEUSER COMPANY
Tacoma, WA 98477 (US)</p> <p>㉖ Inventor: BATTAN, Howard R.
25432-44th Avenue South
Auburn, WA 98002 (US)
Inventor: BENTVELZEN, Joseph M.
668B Turnbull Road
Sumner, WA 98390 (US)
Inventor: BEPPLE, Henry
421 McGill Road
Kamloops, BC, V2C 1M4 (CA)
Inventor: CROSBY, Gerald D.
Rte. 4, Box 743
Vaslon, WA 98070 (US)
Inventor: FLECK, John A.
39531-254th Ave. S.E.
Enumclaw, WA 98022 (US)
Inventor: JUSTICE, Dennis H.
17227 So. Tapps Drive East
Sumner, WA 98390 (US)
Inventor: MEREDITH, Michael D.
2709 S.W. 346th
Federal Way, WA 98003 (US)
Inventor: TORREGROSSA, Louis O.
7 Spruce Court
Glen Falls, N.Y. 12801 (US)</p> |
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⑦④ Representative: **Patentanwälte Grünecker, Dr. Kinkeldey, Dr. Stockmair, Dr. Schumann, Jakob, Dr. Bezold, Meister, Hilgers, Dr. Meyer-Plath Maximilianstrasse 58 D-8000 München 22 (DE)**

Description

The present invention relates to a process and an apparatus for mixing a wood pulp with a chemical according to the preamble of claims 1 and 18, respectively. Such a process and apparatus is known from EP—A—030158.

The following definitions will be used in this application.

Pulping is the changing of wood chips or other wood particulate matter to a fibres form. Chemical pulping requires cooking of the chips in solution with a chemical and includes partial removal of the colouring matter such as lignin associated with the wood.

Bleaching is the treatment of cellulosic fibres to remove or alter the coloring matter associated with the fibres to allow the fibre to reflect white light more truly.

Consistency is the amount of pulp fibre in a slurry, expressed as a percentage of the total weight of the oven dry fibre and the solvent, usually water. It is sometimes called pulp concentration.

The consistency of the pulp will depend upon the type of dewatering equipment used. The following definitions are based on those found in Rydholm *Pulping Processes*, Interscience Publishers 1965, pages 862—863 and TAPPI Monograph No. 27, *The Bleaching of Pulp*, Rapson editor, The Technical Association of Pulp and Paper Industry, 1963, pages 186—187.

Low consistency is from 0—6%, usually between 3 and 5%. It is a suspension that is pumpable in an ordinary centrifugal pump and is obtainable using deckers and filters without press rolls.

Medium consistency is between 6 and 20%. Fifteen percent is a dividing point within the medium-consistency range. Below 15% the consistency can be obtained by filters. This is the consistency of the pulp mat leaving the vacuum drum filters in the brownstock washing system and the bleaching system. The consistency of a slurry from a washer, either a brownstock washer or a bleaching stage washer, is 9—13%. Above 15%, press rolls are needed for dewatering. Rydholm states that the usual range for medium consistency is 10—18%, while Rapson states it is 9—15%. The slurry is pumpable by special machinery even though it is still a coherent liquid phase at higher temperatures and under some compression.

High consistency is from 20—40%. Rydholm states that the usual range is 25—35% and Rapson states that the range is from 20—35%. These consistencies are obtainable only by presses. The liquid phase is completely absorbed by the fibers, and the pulp can be pumped only very short distances. For practical purposes, it is nonpumpable.

Pulp quantity is expressed in several ways.

Oven dry pulp is considered to be moisture free or bone dry. Its value is determined by drying the pulp in an oven at a temperature of 100 to 105°C until it reaches constant weight. It usually is considered to have reached constant weight after 24 hours in the oven.

Air dry pulp is assumed to have a ten percent moisture content. One air-dry ton of pulp is equal to 0.9 oven-dry tons of pulp.

In the afore-mentioned EP—A—030 158, an apparatus and a process for medium consistency oxygen delignification of pulp is known in which in a series of tubular reaction zones rapid delignification is achieved by agitating the pulp by rotating a timing screw in the first reaction zone at a speed in excess of 10 rpm, modifying the flights on the timing screw to increase the amount of agitation, or a combination of the two. Primary oxigation is carried out in the first reaction zone while subsequent loans provide the retention time needed for the delignification reaction to go to completion.

In this system screw conveyors with specially designed flights are used to simply stir and tumble medium consistency pulp in a pressurised oxygen atmosphere for a given length of time. While some delignification is achieved, approximately 30% to 32%, a good percentage of the fibres are never exposed to oxygen because this type of mixing cannot break up the small clumps of pulp. Some fibres are less delignified than others resulting in none uniformity.

It is the object of the present invention to provide a process and an apparatus by which not only the smallest clumps of pulps are broken up but also the gaseous chemical for the treatment of the pulp is dispersed into extremely fine bubbles throughout the matrix so that a foamy mass is produced resulting in a more uniformly delignified or bleached fibre mass.

This object is attained by the characterising features of claim 1 and 18, respectively. Preferred embodiments of the invention are subject matter of the sub claims.

According to the present invention, it has been decided that it is necessary to shorten the time of reaction to provide equipment that is not capital intensive, and to operate at consistencies usually found in a pulping and bleaching system to reduce the horsepower required to operate the system. Pulp usually leaves the washer or subsequent steam mixer at consistencies of 7 to 15%. It has the same consistency as other places within the pulp mill. The invention proceeded to attempt mixing with equipment that is more suited to a normal pulpable environment, can easily be inserted into the pulp mill without major modifications of the equipment in the mill and requires less power to operate. In order to attain this, the amount of swept area, that is the area swept by rotating members while the pulp slurry is passing through the mixers, is important. This area is defined by the formula:

$$A = \frac{F \cdot R \cdot N}{V}$$

where

- 5 A= area swept per metric ton of pulp
 F= area swept by one rotating member upon one revolution thereof,
 R= revolutions of the rotating member
 N= number of rotating members
 V= weight amount (Oven-Dry Basis) of pulp passing through the mixer.

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It has been discovered that the swept area should be in the range of 10,000 to 1,000,000 square meters per metric ton of oven dry pulp. They determined that within this range there was a range of 25,000 to 150,000 square meters per metric ton of oven dry pulp which had certain characteristics that were better: less power was required or the kinetics of the reaction were substantially better. The optimum swept area is

15 around 65,400 square meters per metric ton of oven dry pulp.

It was also determined that the oxygen should be placed within the pulp slurry in the mixing zone. The oxygen should preferably be supplied incrementally to the pulp as it passes through the mixer. This is done by multiple additions of the chemical through the stators which extend into the pulp slurry and reduce the rotation of the pulp slurry as it passes through the mixing zone.

20 The rotating members which provide the swept area within the slurry have leading and trailing edges with radii of curvature of 0.5 to 15 mm. Although the radii of curvature of the leading and trailing edge usually are the same, they need not be. The rotating member, preferably should have a cross-section having a shape that is elliptically generated, preferably elliptical, with its major axis in the direction of rotation. It should also be tapered. The trailing edge of the rotating member may have a groove within it,

25 and the groove may be treated with a hydrophobic coating.

It was also discovered that the central shaft in the mixer should have a diameter of about one-half of the total interior diameter of the mixer to provide an annular space through which the pulp slurry would pass while being treated. There is a better reaction when the shaft has a diameter that is at least one-half of the inner diameter of the mixer than when a shaft which has a smaller diameter.

30 The mixer should have a mixing zone with a swept area of 10,000 to 1,000,000 square meters per metric ton of oven dry pulp. A preferred range is 25,000 to 150,000 square meters and the optimum range is around 65,400 square meters. The rotating members in the mixer have leading and trailing edges, each with a radius of curvature of 0.5 to 15 mm, and an elliptically generated cross section. The oxygen is introduced into the mixing zone through the stators.

35 The inventors decided to investigate both the need for costly expenditures and for length times in which to do oxygen bleaching. They decided to add oxygen to an existing system and determine the results. They found, contrary to prior art teaching, that the oxygen may be added to the pulp and processed at the consistency at which the pulp normally comes from the washer or subsequent steam mixer, that much of the treatment occurs in less than a minute in the mixer and that a long reaction time or large

40 capital-intensive equipment is not required for oxygen treatment. What is required is relatively small mixing equipment which intensively mixes the pulp and the gas.

The oxygen may be added into an extraction stage, between washers, between a washer and a subsequent storage tank or in the blow line of a continuous digester, after the pulp is washed in the digester. Alkali, steam and oxygen are added to the blow line and the oxygen treated with the pulp. The

45 blow line may carry the pulp to either a storage tank, a diffusion washer or other processing. These are not a necessary part of the oxygen treatment.

Several desirable treatment sequences are possible. These are O—X—O and O—O—X—O in which X is

chlorine, chlorine dioxide, a combination of chlorine and chlorine dioxide, a hypochlorite, a peroxide or

50 ozone. The sequence may be followed by a D step, O being oxygen, D being chloric dioxide.

Though the mixer was originally designed to overcome a problem in the oxygenation of pulp, it is also useful for gases which are noncondensable in said pulp such as ozone, air, chlorine, chlorine dioxide, sulfur dioxide, ammonia, nitrogen, carbon dioxide, hydrogen chloride, nitric oxide and nitrogen peroxide. These gases may also be described as unsaturated in that they will not condense into liquid but will be superheated even after contact with the pulp. The mixer may also be used to mix highly superheated steam

55 with the pulp. Figure 1 is a diagram of an oxygen system to which the invention may be applied and used in the blow line in conjunction with a refiner.

Figure 2 is a diagram of the oxygen system in an extraction stage.

Figure 3 is a diagram of the oxygen system between washers.

60 Figure 4 is a diagram of the oxygen system between a washer and storage.

Figure 5 (A—C) is a diagram of a pulping and bleaching process using the oxygen bleaching systems of Figures 2, 3 and 4, and a modification of Figure 4.

Figure 6 (A—C) is a diagram of a pulping and bleaching process using the oxygen bleaching system of Figure 4, and a modification of Figure 4.

65 Figure 7 is an isometric view of a mixer that may be used in the present invention.

Figure 8 is a side plan view of the mixer shown in Figure 7.

Figure 9 is a cross section of the mixer taken along line 9—9 of Figure 8.

Figure 10 is a cross section of the mixer taken along line 10—10 of Figure 9.

Figure 11 is a plan view of a rotating element or rotor.

5 Figure 12 is a cross section of the rotor taken along line 12—12 of Figure 11.

Figure 13 is a plan view, partially in cross section, of a modified rotor.

Figure 14 is a cross section of the modified rotor taken along line 14—14 of Figure 13.

Figure 15 is a plan view, partially in cross section, of a stator which may be used with the mixer.

10 Figure 16 is a side plan view, partially in cross section, of a modified stator taken along a line corresponding to line 16—16 of Figure 15.

Figure 17 is a cross section of the stator taken along line 17—17 of Figure 24.

Figure 18 is a cross section of a valve taken along line 18—18 of Figure 16.

Figure 19 is an isometric view of a modified mixer.

Figure 20 is a side plan view of the mixer of Figure 19.

15 Figure 21 is a cross section of the mixer taken along line 21—21 of Figure 20.

Figure 22 is a cross section of the mixer taken along line 22—22 of Figure 21.

Figure 23 is a cross section of a rotor used in the reactor of Figures 19—22.

Figure 24 is a cross section of the rotor taken along line 24—24 of Figure 23.

Figure 25 is a graph comparing two mixers.

20 Figure 26 is a cross section of a modified mixer.

Figure 27 is a cross section of the modified mixer taken along line 27—27 of Figure 26.

Figure 28 is an enlarged cross section of the interior of the mixer shown in Figure 26.

Figures 1—4 show the invention applied in the blow line at the refiner. Figure 1 is a diagram of the process to add oxygen to the pulp slurry.

25 The system shown in Figure 1 merely requires adding the oxygen, alkali and heat prior to a refiner in a standard continuous digester blow line refining system. In a two-refiner system, the second refiner is preferable because there are more individual fibers in this stage. This is the system shown in Figure 1.

30 In this figure, the reference numerals 10' being incoming chips, 11' being process water, 12' being steam, 13' being pulping chemicals, and 14' being a continuous digester. The chips 10' may be treated prior to entering the digester 14' by presteaming or impregnation with digestion chemicals or any other type of treatment. Any type of pulping process may be used, and the pulping conditions for a particular process will depend upon the species of wood chip and the product desired. The pulping conditions and the amounts of chemical are well known.

35 The digester 14' should be continuous because a major portion of the delignification products should be removed prior to the oxygen treatment. Otherwise too much of the oxygen will be used in reaction with the delignification products and not with the pulp fibers. The washing stage of the continuous digester provides this washing. Reference numerals 15' and 16' refer respectively to the wash water entering and the effluent leaving the washing stage of the continuous digester.

40 Reference numerals 17', 20', and 21' are three sections of a blow line, 18' and 19' are two refiners, 22' is a storage tank or a diffusion washer and tank, and 23' and 24' are a pump and a line carrying pulp from the tank 22' to further processing.

45 The purpose of the present invention is to treat the washed pulp with oxygen with as little change to the equipment as possible. Sodium hydroxide and steam are added to the pulp slurry in line 20' between refiners 18' and 19'. Sodium hydroxide, which both adjusts the pH of the pulp and buffers the oxygen reaction, is added through line 25. Other suitable alkalies, such as white liquor, may also be used. Steam is added through line 26. The steam raises the temperature of the pulp to a temperature appropriate for the oxygen treatment. Oxygen is added to the pulp through line 27. In a two-refiner system, the addition of the chemicals and steam prior to the second refiner is preferable because there are more individual fibers in the second refining stage.

50 The lines used to carry these various chemicals to the process are shown in the upper section of Figure 1. Line 360' carries process water to lines 11' and 15'. Line 362' carries sodium hydroxide to line 25. Line 364' carries steam to lines 12' and 26. Line 366 carries oxygen to line 27. In some instances, the alkali is used both as a digestion chemical and for the oxygen treatment, as in the soda process in which sodium hydroxide is used for both digestion and oxygen treatment, or the kraft process in which white liquor is used for both digestion and oxygen treatment. In this case, line 362' would also supply line 13'.

55 The amount of oxygen used will depend upon the yield and K or Kappa number of the pulp to be treated, and the desired result of the treatment. Between 5 to 50 kilograms of oxygen per metric ton of oven-dry unbleached wood pulp is required for the oxygen treatment.

60 In a low yield, low Kappa number pulp the purpose of the oxygen treatment would normally be bleaching. The actual yield and Kappa number would depend on the pulping process used, but these pulps are used for bleached products. The blow line and brownstock Kappa number for pulp being used in bleached products is usually around 30 to around 40. The amount of oxygen used to bleach the pulp would be between 5 and 40 kilograms per metric ton of oven-dry pulp.

65 In a high yield, high Kappa number pulp of the type usually used for linerboard the purpose of the oxygen treatment is to improve certain properties of the product. The blow line and brownstock Kappa

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number for this pulp is usually around 80 to 120. This allows the mill either to increase certain property values of the product at the same pulp yield or to maintain the property value while increasing the yield. As an example, the application of 12 to 50 kilograms of oxygen to a high yield, high Kappa number pulp will either increase the ring crush of a liner prepared from the pulp or maintain the ring crush at the same value and increase the yield. Ring crush is determined by TAPPI Standard T818 OC-76.

Other conditions may need adjustment for oxygen treatment. The pH for any oxygen treatment in any environment should be between 8 and 14. In this environment, the amount of alkali, expressed as sodium hydroxide, required to obtain this pH is between 0.25 to 8% of the oven-dry weight of the unbleached wood pulp. The temperature for any oxygen treatment in any environment is usually between around 65°C to around 121°C. The usual oxygen stage temperatures are around 82°C to around 99°C. However, the actual temperature in any oxygen stage will depend upon the ability to heat the pulp, so it may vary from around 65°C to around 121°C depending on the location of the oxygen stage in the system. The pulp from the digester may be at the temperature required for the oxygen reaction. If not, the pulp would be heated to either adjust it to or maintain it at the temperature required for the oxygen reaction during the mixing step.

In Figure 1, there are three sample points labelled A, B and C. A is in the blow line 17' after the continuous digester 14'; B is in the blow line 21' after refiner 19'; and C is in the outlet from storage tank 22'. These are the three points at which samples were taken and tested in a mill trial of this system.

The pulp left the continuous digester 14' at 71°C and 1380 kPa gage. Its pH was 10.5. The amount of unbleached pulp passing through the system from the digester throughout the test was 14.3 oven-dry metric tons per hour. The pulp passed through the refiner 19' in up to about 1.5 seconds, and remained in storage tank 22' about 50 minutes. The storage tank 22' was open to the atmosphere, and blow line 21' poured the slurry into the open tank.

The system was first tested for a period of approximately 6 hours to determine the amount of residual lignin in the unbleached pulp at point A and point C to determine if there were any bleaching effects in a standard system. Samples were taken at points A and C at the time intervals indicated in Table I, and the Kappa number of each of the samples was determined. The accuracy of the measurements of these discrete samples was checked during the test by taking a number of samples, averaging the Kappa numbers of these samples and comparing this average to the Kappa number of the discrete sample. These, the A Avg and C Avg Kappa numbers in Table I, and the discrete sample Kappa numbers are within experimental accuracy.

The various Kappa numbers for the samples of unbleached pulp are shown in Table I.

TABLE I
Kappa number

Time	A	C	Diff	A Avg	C Avg
0:01	28.0				
0:35		35.4			
1:00	33.2				
1:30		31.2			
2:00	32.4				
2:30		31.9			
3:00	32.0			32.5	
3:30		29.9			32.7
4:00	37.6				
4:30		38.7			
5:00	36.4				
5:30		36.8			37.8
Avg	33.3	34.0	+0.7		

From these results, it can be seen that no bleaching occurred between sample point A, the outlet of the continuous digester 14', and sample point C, the outlet of storage tank 22'.

Following the 6-hour control test without oxygen there was a 5-1/4 hour test using oxygen. The pH and temperature were between 7 and 14 and between around 65°C and around 121°C respectively.

During this test, the amount of oxygen added to the pulp was measured approximately every half hour and recorded as pounds of oxygen added per hour. This has been converted to kilograms. Since the flow of unbleached pulp was substantially constant at 14.3 oven-dry metric tons per hour, it was possible to determine the amount of oxygen added in kilograms of oxygen per oven-dry metric ton of unbleached wood pulp.

During the test, the oxygen flow varied from a low of 6.7 kilograms per oven-dry metric ton of unbleached pulp to a high of 40 kilograms per oven-dry metric ton of unbleached pulp. The average oxygen rate was 15 kilograms per oven-dry metric ton of unbleached pulp. Sodium hydroxide was added at a rate of 64 kilograms per oven-dry metric ton of unbleached pulp, and the steam was added at a rate of 612 kilograms per oven-dry metric ton of unbleached pulp. The pulp entered the second refiner 19' at a temperature of 70—97°C, a pressure of 621 kPa gage and a pH of 12.5.

Pulp samples were again taken at points A and C at the time intervals indicated in Table II and the Kappa numbers of the pulp sample measured. This was to determine whether the oxygen bleached the pulp. These Kappa numbers are given in columns A₁ and C₁ in Table II. The Kappa number at point C was on the average, 7.5 points less than the Kappa number at point A during the oxygen treatment, showing that bleaching occurred.

Another series of tests were made to determine where bleaching occurred in the system.

In the first part of these tests, samples were taken again at points A and C to see if there was a correlation between these tests and the other A₁—C₁ bleaching tests being made at the same time. The results of these correlation tests are in columns A₂ and C₂ in Table II. It may be seen that the average Kappa number drop for the A₂ and C₂ tests, 7.8, and the Kappa number drop for the A₁ and C₁ tests, 7.5, are within experimental accuracy.

The second part of the tests was done during the A₂—C₂ tests. Samples were also taken at A and B and the Kappa numbers determined. The samples at B were taken at approximately the same time as the samples at A because the pulp is in the refiner 19' for up to about 1.5 to 2 seconds. The maximum time in the refiner would be 10 seconds. The results of these are in columns A₂ and B of Table II. From these tests it can be seen that the Kappa number drop across the refiner 19' was 7.5, substantially the entire Kappa number drop between point A and Point C. These tests indicate, within experimental accuracy, that the entire Kappa number drop, or delignification, occurs in the refiner between points A and B. The first Kappa number at B, 28.5, is the same as the corresponding number at C₂, and the second Kappa number B, 31.4, is almost the same as the corresponding number at C₂, 31.5. Consequently, these tests have shown that bleaching occurs in the refiner 19' between the oxygen addition and point B.

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TABLE II

5	Time	O ₂ kg/hr	O ₂ kg/ODt	Kappa number										
				A ₁	C ₁	Diff	A ₂	C ₂	Diff	A ₂	B	Diff	Avg	
	6:00			35.0										36.3
	6:30				26.4									
10	6:32	196	13.7											
	7:00	381	26.7	35.4										
15	7:30				27.2									
	7:32	95	6.7											
	7:45						36.3							
20	8:00			35.1			37.4							
	8:02	238	16.7											
25	8:15						36.8	28.0						
	8:30				23.2			28.3						
	8:31	191	13.3											
30	9:00	191	13.3	36.0			37.4	29.7		37.4	28.5	-8.		
	9:30				28.7			28.5						
35	9:40	179	12.5											
	10:00			32.1			37.4			37.4	31.4	-6.0		
	10:05	286	20											
40	10:15	429	30											
	10:30				29.0			31.5						
45	10:35	143	10											
	10:50	191	13.3											
	10:55	572	40											
50	11:15				28.8									
	Avg	214	15	34.7	27.2	-7.5	37.0	29.2	-7.8	37.4	29.9	-7.5		

55 The brightness of samples taken at points A and C was also checked. The average brightness of A₂ pulp samples was 18.9 and of C₂ pulp samples was 22.3.

60 During the oxygen tests, a number of other measurements were taken. The shives, unbroken fiber bundles, were measured at points A and C. The average shive content was 2.2 percent of the oven-dry weight of the pulp at point A, and 0.67 percent of the oven-dry weight of the pulp at point C. The filtrate solids in the blow line material were 3.6 percent of the oven-dry weight of the pulp.

The physical properties of the pulp were also tested. These properties were freeness, burst, tear, fold, breaking length and density.

65 The results of these tests are given in Table III. Three sets of data are given. The first set is for an average of all the bleached pulps tested. The second set is for a specific sample of pulp. The third set is for a

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control and is an average of tests of unbleached pulps produced on the apparatus before and after the bleaching trial.

TABLE III

Physical test		Test pulp avg	Test pulp sample	Control pulp
Initial CSF		703	708	715
Time to	550 CSF	30 min	29 min	34 min
Time to	400 CSF	49 min	50 min	53 min
Time to	250 CSF	67 min	68 min	70 min
Burst	Initial	14.3	12.1	12.8
Burst @	550 CSF	64.4	62.1	67.1
Burst @	400 CSF	72.7	69.7	72.4
Burst @	250 CSF	75.6	73.1	74.3
Tear	Initial	229	206	225
Tear @	550 CSF	176	179	159
Tear @	400 CSF	160	157	151
Tear @	250 CSF	151	149	147
Fold	Initial	7	11	5
Fold @	550 CSF	610	705	545
Fold @	400 CSF	1045	1045	660
Fold @	250 CSF	1570	1365	810
Breaking length	Initial	2700 m	2700 m	2700 m
Breaking length @	550 CSF	7700 m	7300 m	8000 m
Breaking length @	400 CSF	8700 m	7800 m	8500 m
Breaking length @	250 CSF	900 m	8200 m	8900 m
Density	Initial	.49	.49	.47
Density @	550 CSF	.58	.58	.58
Density @	400 CSF	.61	.62	.62
Density @	250 CSF	.62	.63	.62

It was necessary during this test that the means for adding the oxygen, steam, and sodium hydroxide be of the simplest possible type. In each instance, the chemicals were added through pipes extending into the blow line 20'. The lines were upstream of refiner 19'.

To determine the ability of oxygen to change the properties of pulp, a pulp having a Kappa number of 120 and a yield of 58.6 was treated with oxygen in pilot plant equipment. The equivalent of 20 kilograms of oxygen per metric ton of oven-dry pulp was applied to the pulp. The temperature was 90°C. Sodium hydroxide addition was 4% of the weight of the oven-dry pulp. No protector, such as magnesium oxide, was added. In fact, no protector was used in any of the experiments described in this application.

The treated pulp had a Kappa number of about 65. It was compared to a kraft pulp having a 58 Kappa number. The tests were at 675 Canadian Standard Freeness. The oxygen treated pulp had a ring crush 15% greater than the kraft pulp and a burst 2% greater than the kraft pulp.

Again the actual chemical application will depend upon the starting pulp and whether it is desired to increase properties or yield. The oxygen application may be from 12 to 50 kilograms per metric ton of oven-dry pulp. The alkali addition, expressed as sodium hydroxide, would normally be from 3.6 to 4.9% and the temperature would normally be from 82 to 95°C. A slight amount of protector might be used. This would not exceed 0.5% based on the weight of the oven-dry pulp.

The final product would have a Kappa ranging from 65 to 69; a ring crush, compared to a kraft pulp, of from 3% less when yield is increased to 28% more if better properties are desired; and a burst, compared to kraft pulp, of the same number if yield is increased to 6% greater if better properties are desired.

Much of the treatment would occur in the mixer and a majority in the mixer and through to the back pressure valve or top of the pipe in the mixer outlet line.

Figure 2 shows the oxygen mixer in a standard caustic extraction stage of a bleaching system. It shows that a simple change can turn a caustic extraction stage into an oxygen treatment stage.

The pulp 195' enters washer 201' where it is washed, dewatered and treated with alkali, usually sodium hydroxide. The consistency of the pulp leaving the washer is usually in the range of 8 to 15%. The exiting pulp 203' then is mixed with the alkali and steam in steam mixer 206'. Pulp consistency is reduced about

1% in the steam mixer. From the steam mixer the pulp goes to extraction tower 213' where it remains for the usual period of time. It is diluted and carried to washer 221', where it is washed and dewatered.

Although washer 221' may be a diffusion washer, it is shown and described as a vacuum or pressure drum washer.

5 In washer 221' the water is either fresh process water through line 310', counterflow filtrate through a line 343' or a combination of these, and in washer 201' the wash water is either fresh process water through line 290', or counterflow filtrate through line 323', or a combination of these.

The filtrate from washer 201' is stored in seal tank 293' and is used as dilution water through lines 295', 297' and 301', as wash water through line 303', or sent to effluent treatment through line 294'. It is shown
10 being treated separately from effluent in line 350' because the effluent, if from a chlorine stage, would be treated separately from effluent from an oxygen stage.

Similarly, the filtrate from washer 221' is stored in seal tank 313' and used as dilution water through lines 315', 317' and 321', as wash water through line 323', or treated as effluent through line 314'. Since the oxygen effluent has little, if any, chlorine components, it may be combined with the effluent from the
15 brownstock washers and the digester and be treated in the recovery furnace thus reducing the amount of material that must be sewerred to an adjacent stream or body of water.

The supply lines are 360''' for process water, 362''' for sodium hydroxide solution, and 364''' for steam.

According to Fig. 2, the pulp leaves steam mixer 206' through line 209'A and enters oxygen mixer 211
20 and the oxygenated pulp leaves mixer 211 through line 209'B and enters the extraction tower 213'. The amount of oxygen supplied to the pulp would be 11 to 28 kilograms per metric ton of oven-dry pulp. A preferred range is 17 to 22 kilograms of oxygen per metric ton of oven-dry pulp.

The temperature would normally be increased from 71—77°C for an extraction stage to 82—88°C for an oxygen treatment stage, because the treatment is improved at higher temperatures. The temperature may
25 be as high as 121°C. The amount of alkali, expressed as sodium hydroxide, is 0.5 to 7% of the weight of the oven-dry pulp. Channeling of the oxygen after mixing is of no particular consequence. If the extraction tower was a downflow tower, it remains a downflow tower. The physical location of mixer 211 is a matter of convenience, the simplicity of installation and maintenance being the sole criteria. If it can be placed in an existing line, it will be. If convenience requires that it be placed on the floor of the bleach plant, it will be
30 placed on the floor of the beach plant and an external pipe can carry the pulp slurry to the top of the extraction tower 213'.

The mixing produces an intimate contact between the gas and the slurry, and appears to divide the gas into mostly small bubbles. There may be some larger bubbles and gas pockets, however. The presence of
35 some large bubbles and gas pockets up to the size of the pipe through which the pulp slurry was passing have been observed. These have not effected the quality of the pulp or the treatment of the pulp.

Again there should be a back pressure on the pulp in the mixer. This may be provided by an upflow line after the mixer which creates a hydrostatic head at the mixer. A pressure valve is preferred. The valve may
40 be combined with the upflow line. The valve may be placed in the line 209'B downstream of the mixer 211. The valve may be either right after the mixer or at the top of the line before the outlet.

The maximum pressure in the mixer would normally not exceed 830 kPa gage, and the top of the pipe
45 would normally not exceed 345 KPa gage.

In a mill trial of the system, sampling was done at D, E and F. At point E, sampling was at the top of the tower 213' rather than directly after the mixer 211 because it was not possible to sample after the mixer. It
50 required about 1 minute for the slurry to reach point E from the mixer. In these tests the mixer was on the bleach plant floor and an external line carried the slurry to the top of the tower.

TABLE IV

PBC

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	D	E	F
	1.4	1.13	0.95
	1.41	1.13	0.90

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Figure 3 shows the oxygen mixer between two washers. In this case the washers are brownstock washers.

There are, among others, a steam mixer 86, a pump 76, a mixer 88, and lines 85, 87 and 89. Line 85 adds
60 alkali onto the mat 73'A as it is leaving the washer 71'. The amount of alkali, expressed as sodium hydroxide, placed on the mat is between 0.1 and 6%, preferably between 2 and 4%, based on the oven-dry weight of the pulp. The treated mat 73'A is then carried to steam mixer 86 in which it is mixed with the alkali and with steam from line 87 to increase the temperature of the pulp to 65—88°C and possibly as high as 121°C. From steam mixer 86 the pulp slurry 73'B is carried by a pump 76 to a mixer 88 in which it is mixed with oxygen from line 89. The amount of oxygen added will depend upon the K number of the pulp and the
65 desired result. The reasons for adding oxygen in the brownstock washers are the same as for adding it in

0 087 412

the blow line and the same amounts would be used. This will normally range from 5 to 50 kilograms per metric ton of oven-dry pulp. Two standard ranges for bleaching in a brownstock system are 22 to 28 and 8 to 17 kilograms of oxygen per metric ton of oven-dry pulp. The latter is a preferred range. The oxygenated pulp 73°C then passes to the vat 90' of washer 91'.

5 The washer after the mixer may be a diffusion washer.

Again there should be a back pressure on the mixer. This pressure is provided in the same way that the pressure is provided to mixer 211, by an upflow line, a pressure valve or a combination of these. The placement of the valve and the maximum pressure are the same as those for mixer 211.

Figure 4 discloses a system placed between a washer such as brownstock washer 91'' and a storage
10 tank such as storage tank 110'. There are a steam mixer 106, a mixer 108, an alkali line 105 and its supply line 362''''', a steam line 107 and its supply line 364''''', and an oxygen line 109 and its supply line 366'''''. The amount of alkali and oxygen added to the pulp, the temperature of the pulp, and the time between alkali addition and oxygen addition and the pressure at the mixer and in the outlet line and the methods of obtaining these pressures are the same as in the system of Figure 3.

15 In each of these systems, the time between alkali addition and oxygen addition is usually from 1 to 5 minutes. The exact time will depend upon equipment placement and pulp speed.

A mill trial was run using the system shown in Figure 4. In this system, the mixer 108 was floor mounted and the pipe 93''C carried the slurry from mixer 108 to the top of tower 110'. The tower was open to the atmosphere. A partially closed valve near the outlet of pipe 93''C created a 276 kPa gage back
20 pressure in the line. The hydrostatic pressure in the line was 241.5 kPa gage, so the pressure within the mixer was 517.5 kPa gage.

Four trial runs were made under slightly different conditions to determine both the overall delignification effect of the system and the percentage of delignification taking place within each section of the system. K number measurements were taken before and after mixer 108, at the outlet of pipe 93''C, at
25 the outlet of tank 110', and at the outlet of the decker 121' downstream of the tank 110'.

In a control run in which no oxygen was added to the system, it was determined that the K number was reduced by 1 number between the inlet of mixer 108 and the outlet of decker 121'. This probably was due to screening. In the overall delignification computation, the numbers were corrected for this 1 K number drop.

The various K numbers were taken within the system to determine the percentage of the total delignification or K number reduction taking place through the mixer 108, through pipe 93''C, through tank
30 110', and through decker 121'. Washer showers had been added to the decker for these tests. The slurry required between 10 to 15 seconds to pass through mixer 108, 2-1/2 to 3-1/2 minutes through pipe 93''C, and 1/2 to 3 hours through tank 110' or decker 121'. It was determined that in these tests, 30% of the total delignification occurred in mixer 108, 40% occurred in pipe 93''C, 8% occurred in tank 110', and 21%
35 occurred between the tank and the decker. This latter reduction is caused by screening of the pulp.

Table V gives the actual conditions in the mixer: the temperature in degrees C; the kilograms of caustic, expressed as sodium hydroxide, and oxygen per oven-dry metric ton of pulp; the pressure in kilopascals gage; the K numbers at the various locations within the system; and the percent K number
40 reduction. In Run No. 1, the percent reduction at the decker outlet in the last line is the reduction between the tip of the pipe and the decker outlet.

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0 087 412

TABLE V

		Runs			
		1	2	3	4
5	Mixer conditions				
	Temp. °C	79.5	82	93	88
	Caustic, kg/O.D.t.	15.1	20.2	15.1	20.2
	Oxygen, kg/O.D.	22.7	25.2	20.2	25.2
	Pressure, kPa gage	517.5	517.5	517.5	517.5
10	Overall delignification				
	Before mixer				
	K No.	19.6	25.4	19.9	24.1
	K No. corrected	18.6	24.4	18.9	23.1
15	After decker				
	K No.	15.6	19.2	15.1	17.8
	% No. reduction	16	21	20	23
20	Delignification within system				
	Mixer inlet				
	K No.	19.6	25.4	19.9	24.1
25	Mixer outlet				
	K No.	18.5	23.3	18.6	21.3
	% of Total reduction	25	34	27	29
30	Top of pipe				
	K No.	16.8	21.5	16.0	19.8
	% of Total reduction	44	29	54	40
35	Tank outlet				
	K No.	—	20.5	16.0	19.3
	% of Total reduction	—	16	0	8
40	Decker outlet				
	K No.	15.6	19.2	15.1	17.8
	% of Total reduction	31	21	19	23

This data indicates that in any of the systems described in this application, a valve should be placed in the line downstream of the oxygen mixer to provide back pressure on the mixer. It also indicates that much of the delignification occurs in less than a minute in the mixer. It may be in 10—15 seconds or less. Most will occur in a few minutes in the mixer and the outlet pipe immediately after the mixer.

The maximum pressure in a mixer would normally not exceed 830 kPa gage, and the pressure at the top of the pipe if a hydrostatic leg is used would normally not exceed 345 kPa gage.

The mixer has also been operated under a hydrostatic pressure only.

The oxygen systems of Figures 2, 3 and 4 are shown in a bleaching system in Figure 5. Figure 5 shows an overall system and shows digestion, brownstock washing, screening, and an OOCOD bleach sequence, C being chlorine.

Essential portions of the system in Figure 5 are indicated by brackets at the bottom of Figure 5.

Indicated by bracket 430 is the washer oxygen system of Figure 3 and again the reference numerals and operating conditions for this oxygen stage are the same as that given for the oxygen stage in Figure 3. Since an oxygen treatment stage should have washed pulp, the oxygen stage 430 in Figure 4 is shown after the third brownstock washer to indicate its placement after a batch digester in which no washing would occur in the digester. With a continuous digester, there would be fewer brownstock washers, and the oxygen stage could be earlier in the brownstock system.

Shown by bracket 431 is a modification of the washer oxygen system of Figure 4. There should be at least two stages of washing after an oxygen bleach stage. The two washing stages after the oxygen stage at bracket 430 are washer 91''' and decker 121' which is converted to a washer. If the oxygen stage at bracket 430 had been after the second brownstock washer 51' rather than the third brownstock washer 71'', then the oxygen system 431 could have been between washer 91''' and storage tank 110'' as shown in Figure 4.

In the system shown, the decker 121' has been converted to a washer by the addition of washer heads 125, a process water line 127 and a clean-up washer 124. The system has been further modified into an oxygen system by the addition of an alkali line 425, a steam mixer 426, a steam line 427, an oxygen mixer

O 087 412

428 and an oxygen line 429. These are placed between the decker 121' and the high-density storage tank 140'. The operation is the same as that described for Figure 4.

Bracket 432 shows, in dotted line, the elimination of the chlorine and chlorine dioxide equipment usually used in such installations. The chlorine dioxide mixer 144', the chlorine dioxide tower 146', the chlorine aspirator 153', the chlorine mixer 155', the chlorine tower 157', and the pump 159' are eliminated. The piping and chemicals associated with this equipment are also eliminated.

Bracket 433 indicates the elimination of the usually used extraction equipment between washers 161' and 181' so that these washers may be used as the two stages of washing after the oxygen stage at bracket 431. This is also indicated by the elements in dotted line. The eliminated items are the steam mixer 166', the extraction tower 173', and the pumps 170', 176', 278' and 282'. Again, the piping and chemical additions required by an extraction stage are also eliminated. The pump 170' may be retained to move the pulp 163' to washer 181' if this is necessary.

Bracket 434 indicates the elimination of a chlorine dioxide stage and bracket 435 its replacement by a chlorine mixer. The elimination of the chlorine dioxide stage results in the elimination of a steam mixer 186', chlorine dioxide mixer 191', chlorine dioxide tower 193', and pumps 190', 196', 298'' and 302'', their associated piping and chemicals. These are replaced by a small chlorine mixer 438 and the chlorine supply line 151'. A chlorine tower is not required. The pump 190' may be retained if it is required to move the pulp 183' to the mixer 430. The chlorine effluent in line 294'' is maintained separate from the oxygen effluent.

The time in this mixer, as in the oxygen mixer, is less than 1 minute, and normally would be only a few seconds. Pulp travelling at 18.3 meters per second would pass through an 2.4 or 3 meter long reactor in an exceedingly short time. The chlorine would be treated at the temperature of the pulp off the washer, 54 to 60°C, rather than the cooler chlorination temperature.

Bracket 436 shows the oxygen addition to an extraction stage as shown in Figure 2. The reference numerals and operating conditions are again the same as in Figure 2.

Each of the gas mixers should be under a back pressure as described earlier.

Figure 6 shows another arrangement in which the bleach sequence is OCODED. The changes between Figures 6 and Figure 5 are shown by bracket 437. This is the addition of E and D stages at the end of process. Again, the process conditions for this last extraction stage are the same as those for the other extraction stages and for this last chlorine dioxide stage are the same as those for the other chlorine dioxide stages. It should also be realized that the only additional equipment required for these two stages are the two additional washers. The extraction equipment that was eliminated at 433' can be used in this extraction stage and the chlorine dioxide equipment eliminated at 434' can be used in this chlorine dioxide stage. In an actual modification, this equipment would be left in place and repiped.

For the purposes of the present description, however, new reference numerals will be used for these last stages.

In the E stage, the steam mixer is 446, the alkali line 447, the steam line 448, the slurry line 449, the pump 450, the extraction tower 453, the dilution zone 454, the line from the tower to the washer 455 and the pump 456.

In the extraction washer, the vat is 460, the washer 461, the drum 462, the exiting pulp 463, the cleanup washer 464, the incoming process water 490, the washer heads 491, the filtrate line 492, the seal tank 493, the effluent line 494, the dilution lines 495, 497 and 501 and their respective pumps 496, 498 and 502, and the counterflow wash water line 503 and its pump 504.

In the last chlorine dioxide stage, the steam mixer is 466, the alkali line 467, the steam line 468, the pulp slurry line 469, the pump 470, the chlorine dioxide mixer 471, the chlorine dioxide line 472, the chlorine dioxide tower 473, the dilution zone 474, the line from the tower to the washer 475, its pump 476, and the sulfur dioxide lines 477 and 478.

In the last washer, the vat is 480, the washer 481, the drum 482, the exiting pulp 483, the cleanup washer 484, the incoming process water 510, the washer heads 511, the filtrate line 512, the seal tank 513, the effluent line 514, the dilution lines 515, 517 and 521 and their pumps 516, 518 and 522, and the counterflow wash line 523 and its pump 524.

Again, each of the gas mixers should be under a back pressure, as described earlier.

The remaining figures show several types of mixer that may be used with these systems. The exterior is the same in each; however, the internal structure does change.

In Figures 7—10 the mixer 550 has a cylindrical body 551 and two head plates 552 and 553. The pulp slurry enters through pipe 554, passes through the body of the mixer and exits through pipe 555. The oxygen manifolds 558, which supply oxygen to the stators 580 within the mixer, are supplied by oxygen lines 559.

A shaft 560 extends longitudinally of the mixer and is supported on bearings 561 and 562 and is rotated by rotational means 563. A chain belt drive is shown, but any other type of rotational means may be used.

Rotors 570 are attached to the shaft 560. A typical rotor construction is shown in Figures 11 and 12. The rotating element or rotor 570 has a body 571 which is tapered outwardly from the shaft and has an elliptically generated cross section. The preferred cross section is an ellipse. The major axis of the rotor is aligned with the direction of rotation of the rotor. Each of its leading and trailing edges 572 and 573 has a radius of the curvature in the range of 0.5 to 15 mm. The radii are usually the same, though they need not be. If different, then the leading edge would have a greater radius than the trailing edge.

0 087 412

A modification is shown in Figures 13 and 14. A groove 574 is formed in the trailing edge 573' of the rotor. The groove is about 0.1 mm across. The groove may be coated with a hydrophobic material.

The number of rotors and the speed of the rotors will depend on the amount of pulp passing through the mixer and the consistency of the pulp passing through the mixer. The area swept by the rotors should
5 be in the range of 10,000 to 1,000,000 square meters per metric ton of oven-dry pulp. The preferred range is 25,000 to 150,000 square meters per metric ton of oven-dry pump. The optimum is considered to be around 65,400 square meters per metric ton of oven-dry pulp. This area is determined by the formula

$$10 \quad A = \frac{F \cdot R \cdot N}{\dot{V}}$$

where

- A= area swept per metric ton of pulp,
- F= area swept by one rotating member upon one revolution thereof
- 15 R= revolutions of the rotating member
- N= number of rotating members
- V= weight amount (Oven-Dry Basis) of pulp passing through the mixer.

There is a trade-off between the length of the individual rotating members (rotors) and the number
20 thereof. The rotors are usually arranged in rings on the central shaft. The number of rotors in a ring will depend upon the circumference of the central shaft and the size of the rotor base. A greater number of rotors would require a longer and stiffer shaft. Fewer rotors would require longer rotors. Consequently, space for the mixer would determine the actual rotor configuration. Normally, there are a total of 4 to 400
rotors, and from 2 to 20 rotors in a ring.

25 The rotors rotate transversely of the direction of pulp movement through the mixer, describing a helical path through the pulp. The speed of rotation of the rotors would be determined by the motor, and the drive ratio between the motor and the central shaft.

The diameter of the central shaft 560 is at least one half of the internal diameter of the mixer, forming an annular space 568 through which the slurry passes.

30 The enlarged shaft requires scraper bars 564 and 565 on shaft ends 566 and 567. There normally would be four bars on each end. The bars remove fibers that tend to build up between the shaft and the mixer head plate. This prevents binding of the shaft in the mixer.

The stators are shown in Figures 15 to 17. The stators add oxygen to the pulp in the mixing zone and also act as friction devices to reduce or stop the rotation of the pulp with the rotors so that there is relative
35 rotative movement between the rotors and the pulp. Each stator 580 has a body 581, a central passage 582 and a base plate 583. The stators extend through apertures 556 in body 551. There are two ways of attaching the stators. In Figure 24, the stator is attached to the body 551 by a friction fit using a Van Stone flange 584. This allows the stator to be rotated if it is desired to change the oxygen placement. In Figure 25, the base plate 583' is attached directly to the body 551 either by bolts or studs. The oxygen enters the mixer
40 through check valves 590. The stators are round and tapered and the face having the check valves is flattened. The check valves face across a transverse plane of the mixer and in the direction of rotation of the rotors.

The purpose of the check valve 590 is to prevent the pulp fibers from entering the passage 582. A typical check valve is shown in Figure 27. The valve 590 consists of a valve body 591 which is threaded into
45 stator body 581. The valve body has a valve seat 592. The valve itself consists of a bolt 593 and nut 594 which are biased into a closed position by spring 595.

The number of check valves in a stator may vary from 0 to 4. In some mixers, the major portion of the gas would be added at the mixer entrance, requiring up to 4 check valves, and little or no gas would be
50 added near the mixer outlet, requiring 1 check valve or no check valves, and these stators would then only act as friction drag against pulp rotation. For example, between 60 to 70% of the oxygen could be added in the first half of the mixer. The first one third of the stators would have 3 or 4 check valves, the next one third might have 2 check valves, and the last one third might have 1 or no check valves.

The stators may also be arranged in rings. There being one ring of stators for each one or two rings of
rotors. The number of stators in a ring will depend upon the size of the mixer. Usually, there are 4 stators in
55 a ring, but this can normally vary from 2 to 8.

Both the rotors and the stators should extend across the annular space. A normal clearance between the rotor and the inner wall of the mixer, or the stator and the outer wall of the central shaft is about 13 mm. This ensures that all of the pulp is contacted by the oxygen and there is no short circuiting of the pulp
60 through the mixer without contact with oxygen. The rotors and stators should be between the inlet and outlet to ensure that all the pulp would pass through the swept area, and would be contacted with oxygen.

Figures 19—24 disclose a modification to the basic mixer. Oxygen is carried to the rotors through pipe 600 and passage 601 which extends centrally of shaft 560'. Radial passages 602 carry the oxygen to the
outer annular manifold 603. The oxygen passes from the manifold to the pulp through central passage 604 of rotor body 605 and through check valve 590''. These valves are the same as valve 590.

65 The rotor is shown as round and tapered, but its shape may be different. The rotor may be round or

square and nontapered such as those normally found in steam mixers. The round rotors would have radii of curvature exceeding 30 mm. Tapered rotors 606 having a rectangular cross section may also be used.

Figure 25 compares the operation of a modified mixer similar to that shown in Figures 19—24 with the operation of the mixer of Figures 7—18 and indicates the increasing efficacy of the mixer as the swept area is increased and the shaft diameter is expanded. The casing of both mixers was the same. It had an interior diameter of 0.914 m. The inlet and the outlet were the same. In both, the outer radius of the rotor was the same, 0.444 m. Both processed pulp at the same rate, 810 metric tons of oven-dry pulp per day.

The modified mixer had a speed of rotation of 435 RPM. There were 32 stators in 8 rings and 36 rotors in 9 rings. Each ring of rotors had 2 pegs and 2 blades. The blades were rectangular in cross section. The stators and rotor pegs were round, tapered outwardly and 0.254 m long. Oxygen was admitted through the stators only. The diameter of the shaft was 0.38 m and the swept area was 14,100 square meters per metric ton of oven-dry pulp.

The mixer of Figures 7—18 had the same internal diameter but had a central shaft that was 0.508 m in diameter. There were 224 rotors. The rotors were elliptical and linearly tapered. The major axis of the rotor extended in the direction of rotation of the rotor. The leading and trailing edges of the rotor had radii of curvature of 3.8 mm. The rotors were 19 cm long and extended to within about 13 mm of the reactor wall, and the stators extended to within about 13 mm of the central shaft. The speed of rotation of the rotors was 435 RPM. The swept area of the reactor was 72,200 square meters per metric ton of oven-dry pulp. Oxygen was admitted through the stators.

Figure 25 compares the extracted K number of the pulp with the additional K number drop after passing through the mixer, and shows that the mixer achieved a greater K number drop than the modified mixer. It was also found that the mixer needed only half the amount of oxygen as in the modified mixer to obtain the same amount of delignification; that is, with the other operating conditions remaining the same, to achieve the same K number drop, 11 kilograms of oxygen per metric ton of oven-dry pulp were required in the modified mixer, but only 5 kilograms of oxygen per metric ton of oven-dry pulp were required in the mixer. It was also found that the mixer could mix greater amounts of oxygen with the pulp than the modified mixer. Between 1-1/2 to 2 times as much oxygen could be mixed with the pulp with the mixer than with the modified mixer. For example, the modified mixer could mix a maximum of 15.1—20.2 kilograms of oxygen with a metric ton of oven-dry pulp. The mixer could mix 30.2—35.3 kilograms of oxygen with a metric ton of oven-dry pulp.

The optimum swept area is achieved by reducing the number of rotors in the mixer from 224 to 203.

Figures 26—28 illustrate a different type of rotor and stator arrangement and a different type of oxygen admission.

In this modification, an oxygen manifold 610 surrounds the outer body 551' of the mixer and the gas enters the mixer through holes 611 in body 551''. An annular dam 612, located between each ring of holes 611, is attached to the inner wall of body 551''. The dams 612 create a pool of gas adjacent the mixer wall. The stators 585 are attached to the dams 612. The rotors 575 are aligned with the spaces between the dams 612. The outer radius of the rotors 575 is greater than the inner radius of the dams 612 so that the rotors extend beyond the inner wall 608 of the dam into the trapped gas between the dams. This construction allows the rotor to extend into a gas pocket and for the gas to flow down the trailing edge of the rotor as it passes through the pulp slurry.

The rotors and stators may be flat with rounded leading and trailing edges. Again, the radius of curvature of the leading and trailing edges would be in the range of 0.5 to 15 mm, and the radii need not be the same. The rotors and stators may be as narrow as 6.35 mm in width.

This design could also include the groove in the trailing edge of the rotor which may be covered with a hydrophobic coating.

Claims

1. A process of mixing a wood pulp having a consistency of 7% to 15% with a chemical selected from the group consisting of gases non-condensable in said pulp, unsaturated gases and highly superheated steam, comprising:

passing said chemical to said pulp in a mixing zone, and mixing said chemical with said pulp in said mixing zone, said mixing zone having a series of rotating members passing through said pulp and having a major axis extending in the direction of rotation and having leading and trailing edges, characterised by said rotating members passing through said pulp in a direction transverse to the direction of travel of said pulp,

said rotating members providing a swept area through said pulp of 10,000 to 1,000,000 m²/t of oven dry pulp, wherein said swept area is the area swept by the rotating members in an amount of pulp during the passage thereof through said mixing zone and is defined as follows:

$$A = \frac{F \cdot R \cdot N}{V}$$

wherein

A= swept area per metric ton of pulp

F= area swept by one rotating member upon one revolution thereof

N= number of rotating members

V= weight amount of pulp passing through said mixing zone

5 R= number of revolutions of the rotating members within said weight amount of pulp,

said leading edge having a radius of curvature in the range of 0,5 to 15 mm.

2. The process of claim 1 in which said swept area is 14,100 to 1,000,000 m²/t of oven dry pulp.

3. The process of claim 1 in which said swept area is 25,000 to 150,000 m²/t of oven dry pulp.

10 4. The process of claim 1 in which said swept area is around 65,400 m²/t of oven dry pulp.

5. The process of any one of the preceding claims in which said trailing edge has a radius of curvature in the range of 0.5 to 15 mm.

6. The process of any one of the preceding claims in which said chemical is added incrementally to said pulp.

15 7. The process of any one of claims 1 to 5 in which said mixing takes place under a pressure of up to 830 kPa gauge.

8. The process of any one of the preceding claims in which said chemical is selected from the group consisting of oxygen, ozone, air, chlorine, chlorine dioxide, sulphur dioxide, ammonia, nitrogen, carbon dioxide, hydrogen chloride, nitric oxide, and nitrogen peroxide.

20 9. The process of claim 8 comprising intimately mixing said oxygen with said pulp, said mixing occurring in said mixing zone, transporting said pulp to a storage tank and storing said pulp in said storage tank.

10. The process of claim 9 in which the amount of oxygen added to said pulp is 5 to 50 kg/t of oven dry pulp.

25 11. The process of claims 9 or 10 in which said mixing of said oxygen takes place in less than 1 minute.

12. The process of claim 9 further comprising before said mixing step, heating said pulp so that it will be at a temperature in the range of around 65°C to around 121°C during said mixing step.

30 13. The process of claim 8 in which intimate contact is created between said wood pulp and said pulp is treated with said oxygen, comprising adding oxygen to said pulp, mixing said oxygen with said pulp, said mixing occurring in said mixing zone, transporting said pulp to a washer, and washing said pulp in said washer.

35 14. The process of claim 9 in which alkali is added to said pulp in an amount in the range of 0.5% to 7% expressed as sodium hydroxide, based on the oven dry weight of said pulp, and heating said pulp before adding said oxygen in said pulp and mixing the pulp intimately therewith, and in which said treated pulp is stored in said storage tank for a time of 0.5 to 4 hours and, after said storage, washing extraction by-products from said pulp is effected.

40 15. The process of claim 8, comprising treating said pulp with oxygen at an alkaline pH and a temperature of about 65°C to around 121°C, washing said oxygen treated pulp, treating said washed pulp with a bleaching chemical selected from a group consisting of chlorine, chlorine dioxide, combinations of chlorine and chlorine dioxide, hypochlorites, peroxides and ozone, washing said bleaching chemical treated pulp and treating said latter washed pulp at a consistency of 7% to 15% with oxygen at an alkaline pH and a temperature of around 65°C to around 121°C, said oxygen in each of said oxygen treatments being mixed with said pulp in one of said mixing zones.

45 16. The process of claim 8, further comprising forming said pulp by continuously digesting wood chips with chemicals under heat and pressure to form delignification products and delignified wood chips, removing at least a part of said delignification products, forming said pulp from said delignified wood chips by partially releasing the pressure from said wood chips, transporting a slurry containing said wood pulp and remaining delignification products under pressure to a storage tank, and storing said slurry in said tank, prior to said storage, adjusting the pH of said slurry to a pH in the range of 8 to 14, between said pH adjustment and said storage, adding said oxygen to said slurry, between said pH adjustment and said storage, mixing said oxygen with said slurry in said mixing zone.

50 17. The process of claim 8, further comprising forming said pulp by continuously digesting wood chips with chemicals under heat and pressure to form delignification products and delignified wood chips, removing at least a part of said delignification products, forming said pulp from said delignified wood chips by partially releasing the pressure from said wood chips, transporting a slurry containing said pulp and remaining delignification products under pressure to a diffusion washer, washing said pulp in said diffusion washer, prior to said diffusion washing adjusting the pH of said slurry to a pH in the range of 8 to 14, between said pH adjustment and said diffusion washing, adding oxygen to said slurry, between said pH adjustment and said diffusion washing, mixing said oxygen with said slurry in said mixing zone.

60 18. An apparatus for carrying out the process of one of the preceding claims, comprising a casing, an inlet and an outlet in said casing, a shaft in said casing, and a mixing zone in said casing, characterized by a plurality of rotors (570) on said shaft (560) in said mixing zone, said rotors (570) having leading and trailing edges (572, 573), said leading edge (572) having a radius of curvature in the range of 0.5 to 15 mm, said rotors (570) being rotatable through the slurry in a direction transverse to the direction of travel of said

slurry, and said rotors (570) providing a swept area of 10,000 to 1,000,000 m²/t of oven dry solid material in said slurry, said swept area being as defined in claim 1.

19. The apparatus of claim 18 in which said rotors (570) provide a swept area of 14,100 to 1,000,000 m²/t of oven dry solid material in said slurry.

5 20. The apparatus of claim 18 in which said rotors (570) provide a swept area of 25,000 to 150,000 m²/t of oven dry solid material in said slurry.

21. The apparatus of claim 18 in which said rotors (570) provide a swept area of around 65,400 m²/t of oven dry solid material in said slurry.

22. The apparatus of any one of claims 18 to 21 in which said rotors (570) have elliptically generated
10 cross-sections having a major axis extending in the direction of rotation.

23. The apparatus of any one of claims 18 to 21 in which said mixing zone is an annular space (568) in which the interior surface of said space (568) has a radius of at least one half of the radius of the exterior surface of said space (568).

24. The apparatus of any one of claims 18 to 23 in which the trailing edge (573) has a radius of curvature
15 in the range of 0.5 to 15 mm.

25. The apparatus of any one of claims 18 to 21 in which the trailing edge (573') has a groove (574) extending lengthwise of said trailing edge (573').

26. The apparatus of any one of claims 18 to 21 in which said rotors (570) are tapered outwardly.

27. The apparatus of claim 18 or 21, further comprising a plurality of stators (580) extending into said
20 mixing zone from said casing (551), at least some of said stators (580) having a first passage (582) extending from outside of said mixing zone lengthwise through said stator (580) and a second passage communicating between said first passage (582) and said mixing zone, and a check valve (590) in said second passage.

28. The apparatus of claim 18, further comprising a storage tank (110'); means (93'') for transporting
25 said pulp to said storage tank (110'); before said storage tank (110'), means (105) for adding alkali to said pulp, means (109) for adding oxygen to said pulp, and means (108) for mixing said oxygen with said pulp; said mixing means (108) having said mixing zone.

29. The apparatus of claim 28, further comprising a valve in said transportation means (93'') between said mixing means (108) and said storage tank (110').

30 30. The apparatus of any one of claims 28 to 29, further comprising, before said mixing means (420), means for heating said pulp so that it will be at a temperature in the range of around 65°C to around 121°C in said mixing means (420).

31. The apparatus of claim 18, comprising a pulp extraction stage in which said slurry is a pulp, comprising means (201') for adjusting the consistency of said pulp to 7% to 15%; a storage tank (213');
35 means (209') for transporting said pulp from said consistency adjustment means (201') to said storage tank (213'); means (221') after said tank (213') for washing said pulp; means (207') before said tank (213') for adding alkali to said pulp; means (206') between said consistency adjustment means (201') and said tank (213') for heating said pulp; between said heating means (206') and said storage tank (213'), means (212) for adding oxygen to said pulp, and means (211) for mixing said oxygen with said pulp, said mixing means
40 (211) having said mixing zone.

32. The apparatus of claim 18 for creating intimate contact between said slurry and oxygen, said slurry being a pulp having a consistency of 7% to 15%, and treating said pulp with said oxygen, further comprising means (91') for washing said pulp; means (73') for transporting said pulp to said washing
45 means (91'); before said washing means (91'), means (85) for adding alkali to said pulp, means (87) for adding oxygen to said pulp, and means (88) for mixing said oxygen with said pulp, said mixing means (88) having said mixing zone.

33. The apparatus of claim 18 in which said slurry is a pulp slurry comprising means (425) for adding a pH adjustment chemical to pulp, means (429) after said chemical addition means for adding oxygen to said pulp,
50 a mixer (428) for mixing said oxygen with said pulp, a washer (161') after said mixer (428) for washing said oxygen treated pulp, means (151') after said washer (161') for adding a chemical selected from the group consisting of chlorine, chlorine dioxide, a combination of chlorine and chlorine dioxide, hypochlorite, peroxide and ozone to said pulp,

55 a second mixer (438) for mixing said latter chemical with said pulp, a second washer (201') after said second mixer (438) for washing said pulp, means (227') after said second washer (201') for adding a pH adjustment chemical to said pulp, means (212') after said second chemical addition means (227') for adding oxygen to said pulp, a third mixer (211') for mixing said oxygen with said pulp,
60 means (123', 141', 163', 183', 195'', 203'', 209'') for transporting said pulp through said above elements,

each of said mixers having said mixing zone.

34. The apparatus of claim 18 in which said slurry is a pulp slurry further comprising a continuous digester (14'') for continuously digesting wood chips to form delignification products and
65 delignified wood chips, and

a washer (15'', 16'') associated with said digester for removing at least a part of said delignification products,

said digester (14'') having a pressure relief valve for forming wood pulp from said delignified wood chips by partially releasing the pressure from said wood chips,

5 a storage tank (22'),

a pipe (17'', 21'') for transporting a slurry containing said wood pulp and remaining delignification products under pressure from said digester (14'') to a storage tank (22''),

means (25'), prior to said storage tank (22''), for adding a pH adjustment chemical to said slurry, means (27'), between said pH adjustment chemical addition means (25') and said storage tank (22''),

10 for adding oxygen to said slurry, and

a mixer (116), prior to said storage tank (22''), for mixing said oxygen with said slurry, said mixer (116) having said mixing zone.

35. The apparatus of claim 18 in which said slurry is a pulp slurry further comprising

15 a continuous digester (14'') for continuously digesting wood chips to form delignification products and delignified wood chips, and

a washer (15'', 16'') associated with said digester for removing at least a part of said delignification products,

said digester (14'') having a pressure relief valve for forming wood pulp from said delignified wood chips by partially releasing the pressure from said wood chips,

20 a diffusion washer,

a pipe (17'', 21'') for transporting a slurry containing said wood pulp and remaining delignification products under pressure from said digester (14'') to a diffusion washer,

means (25), prior to said diffusion washer, for adding a pH adjustment chemical to said slurry, means (27'), between said pH adjustment chemical addition means (25') and said storage tank (22''),

25 for adding oxygen to said slurry, and

a mixer (116), prior to said diffusion washer, for mixing said oxygen with said slurry, said mixer (116) having said mixing zone.

30 **Patentansprüche**

1. Verfahren zum Mischen einer Holzpulpe mit einer Konsistenz zwischen 7 und 15% mit einer Chemikalie, die aus der Gruppe ausgewählt ist, die aus in der Pulpe nicht kondensierbaren Gasen, ungesättigten Gasen und hoch überhitztem Dampf besteht, enthaltend:

35 Zuleiten der genannten Chemikalie zu der Pulpe einer Mischzone und Mischen der Chemikalie mit der Pulpe in der Mischzone, wobei die Mischzone eine Serie von rotierenden Elementen hat, die durch die Pulpe laufen und eine Hauptachse haben, die sich in der Richtung der Drehung erstreckt, und vordere und hintere Ränder haben, dadurch gekennzeichnet, daß

40 die rotierenden Elemente durch die Pulpe in einer Richtung quer zur Bewegungsrichtung der Pulpe streichen,

die rotierenden Elemente eine überstrichene Fläche durch die Pulpe von 10 000 bis 1 000 000 m²/t ofentrockener Pulpe erzeugen, wobei die überstrichene Fläche die Fläche ist, die von den rotierenden Elementen in einer Pulpenmenge während des Durchlaufs derselben durch die Mischzone überstrichen wird und wie folgt definiert ist:

45

$$A = \frac{F \cdot R \cdot N}{V}$$

wobei

50 A= überstrichene Fläche pro metrischer Tonne Pulpe,

F= von einem rotierenden Element bei einer Umdrehung desselben überstrichen Fläche,

N= Anzahl der rotierenden Elemente

V= Gewichtsmenge der durch die Mischzone strömenden Pulpe

55 R= Anzahl der Umdrehungen der rotierenden Elemente innerhalb der genannten Gewichtsmenge Pulpe

und daß der vordere Rand einen Krümmungsradius im Bereich zwischen 0,5 und 15 mm aufweist.

2. Verfahren nach Anspruch 1, bei dem die überstrichene Fläche 14 100 bis 1 000 000 m²/t ofentrockener Pulpe ist.

60 3. Verfahren nach Anspruch 1, bei dem die überstrichene Fläche 25 000 bis 150 000 m²/t ofentrockener Pulpe ist.

4. Verfahren nach Anspruch 1, bei dem die überstrichene Fläche etwa 65 400 m²/t ofentrockener Pulpe ist.

65 5. Verfahren nach einem der vorhergehenden Ansprüche, bei der hintere Rand einen Krümmungsradius im Bereich zwischen 0,5 und 15 mm hat.

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6. Verfahren nach einem der vorhergehenden Ansprüche, bei dem die Chemikalie der Pulpe schrittweise zugeführt wird.
7. Verfahren nach einem der Ansprüche 1 bis 5, bei dem die Mischung unter einem Druck von bis zu 830 kPa stattfindet.
- 5 8. Verfahren nach einem der vorhergehenden Ansprüche, bei welchem die Chemikalie aus der Gruppe ausgewählt ist, bestehend aus Sauerstoff, Ozon, Luft, Chlor, Chlordioxid, Schwefeldioxid, Ammoniak, Kohlendioxid, Chlorwasserstoff, Stickoxid und Stickstoffperoxid.
9. Verfahren nach Anspruch 8, enthaltend das innige Durchmischen des Sauerstoffs mit der Pulpe, wobei das Durchmischen in der Mischzone stattfindet, Transportieren der Pulpe in eine Speichertank und
- 10 Speichern der Pulpe in dem Speichertank.
10. Verfahren nach Anspruch 9, bei dem die Menge des der Pulpe zugeführten Sauerstoffs zwischen 5 und 50 kg/t ofentrockener Pulpe ist.
11. Verfahren nach Anspruch 9 oder 10, bei dem das Einmischen des Sauerstoffs in weniger als 1 Minute stattfindet.
- 15 12. Verfahren nach Anspruch 9, weiterhin enthaltend vor dem Mischen das Aufheizen der Pulpe derart, daß diese bei einer Temperatur im Bereich zwischen etwa 65°C und etwa 121°C während des Mischschrittes ist.
13. Verfahren nach Anspruch 8, bei welchem der innige Kontakt mit der Holzpulpe erzeugt wird und die Pulpe mit dem Sauerstoff behandelt wird, enthaltend das Zuführen von Sauerstoff zu der Pulpe,
- 20 Durchmischen des Sauerstoffs mit der Pulpe, wobei das Mischen in der Mischzone stattfindet, Transportieren der Pulpe zu einem Wascher und Waschen der Pulpe in dem Wascher.
14. Verfahren nach Anspruch 9, bei welchem Alkali der Pulpe in einer Menge im Bereich von 0,5% bis 7%, ausgedrückt in Natriumhydroxid, auf der Grundlage ofentrockenen Gewichts der Pulpe hinzugefügt wird, die Pulpe vor dem Zuführen des Sauerstoffs zu der Pulpe erwärmt wird und die Pulpe innig damit
- 25 vermischt wird, und wobei die behandelte Pulpe in dem Speichertank für eine Zeit von 0,5 bis 4 Stunden gespeichert wird und nach dem Speichern eine Waschextraktion von Nebenprodukten auf der Pulpe ausgeführt wird.
15. Verfahren nach Anspruch 8, enthaltend das Behandeln der Pulpe mit Sauerstoff bei einem alkalischen pH und einer Temperatur von etwa 65°C bis etwa 121°C, Waschen der mit Sauerstoff
- 30 behandelten Pulpe, Behandeln der gewaschenen Pulpe mit einer Bleichemikalie, die aus einer Gruppe ausgewählt ist, die aus Chlor, Chlordioxid, Kombinationen aus Chlor und Chlordioxid, Hypochloriden Peroxiden und Ozon besteht, Waschen der mit der Bleichemikalie behandelten Pulpe und Behandeln der genannten gewaschenen Pulpe bei einer Konsistenz von 7% bis 15% mit Sauerstoff bei einem alkalischen pH und einer Temperatur von etwa 65°C bis etwa 121°C, wobei der Sauerstoff in jeder der
- 35 Sauerstoffbehandlungen mit der Pulpe in einer der Mischzonen vermischt wird.
16. Verfahren nach Anspruch 8, weiterhin enthaltend das Bilden der Pulpe durch fortlaufendes Kochen von Holzschnitzeln mit Chemikalien unter Hitze und Druck zur Erzeugung von Entlignifizierungsprodukten und ligninfreien Holzschnitzeln, Entfernen wenigstens eines Teils der Entlignifizierungsprodukte, Bilden der Pulpe aus den ligninfreien Holzschnitzeln durch teilweises Ablassen des Drucks von den Holzschnitzeln,
- 40 Transportieren einer Ausschlammung, die die Holzpulpe und die übrigen Entlignifizierungsprodukte enthält, unter Druck zu einem Speichertank und Speichern der Aufschlammung in dem Tank, Einstellen des pH der Aufschlammung von dem Speichern auf einen pH im Bereich zwischen 8 und 14 und Zuführen von Sauerstoff zu der Aufschlammung zwischen der pH-Einstellung und der Speicherung und Mischen des Sauerstoffs mit der Aufschlammung in der Mischzone zwischen der pH-Einstellung und der Speicherung.
- 45 17. Verfahren nach Anspruch 8, weiterhin enthaltend: Bilden der Pulpe durch kontinuierliches Kochen von Holzschnitzeln mit Chemikalien unter Hitze und Druck zur Bildung von Entlignifizierungsprodukten und ligninfreien Holzschnitzeln, Entfernen wenigstens eines Teils der Entlignifizierungsprodukte, Bilden der Pulpe aus den ligninfreien Holzschnitzeln durch teilweises Ablassen des Drucks von den Holzschnitzeln, überführen einer Aufschlammung, die die Pulpe und die übrigen Entlignifizierungsprodukte enthält, unter
- 50 Druck zu einem Diffusionswascher, Waschen der Pulpe in dem Diffusionswascher, Einstellen des pH der Aufschlammung auf einen pH im Bereich zwischen 8 und 14 vor dem Diffusionswaschen, Zuführen von Sauerstoff zu der Aufschlammung zwischen der pH-Einstellung und dem Diffusionswaschen und Mischen des Sauerstoffs mit der Aufschlammung in der Mischzone zwischen der pH-Einstellung und dem Diffusionswaschen.
- 55 18. Vorrichtung zur Durchführung des Verfahrens nach einem der vorhergehenden Ansprüche, enthaltend ein Gehäuse, einen Einlaß und einen Auslaß in dem Gehäuse, eine Welle in dem Gehäuse und eine Mischzone in dem Gehäuse, gekennzeichnet durch:
- mehrere Rotoren (570) an der Welle (560) in der Mischzone, wobei die Rotoren (570) vordere und hintere Ränder (572, 573) haben, wobei der vordere Rand (572) einen Krümmungsradius im Bereich
- 60 zwischen 0,5 und 15 mm hat, die Rotoren (570) durch die Aufschlammung in einer Richtung quer zur Bewegungsrichtung der Aufschlammung drehbar sind und die Rotoren (570) eine überstrichene Fläche von 10 000 bis 1 000 000 m²/t ofentrockenen Feststoffmaterials in der Aufschlammung erzeugen, wobei die genannte überstrichene Fläche wie in Anspruch 1 definiert ist.
19. Vorrichtung nach Anspruch 18, bei der die Rotoren (570) eine überstrichene Fläche von 14 100 bis
- 65 1 000 000 m²/t ofentrockenen Feststoffmaterials in der Auschlammung erzeugen.

20. Vorrichtung nach Anspruch 18, bei der die Rotoren (570) eine überstrichene Fläche von 25 000 bis 150 000 m²/t ofentrockenen Feststoffmaterials in der Auschlammung erzeugen.

21. Vorrichtung nach Anspruch 18, bei der die Rotoren (570) die überstrichene Fläche von etwa 65 400 m²/t ofentrockenen Feststoffmaterials in der Aufschlammung erzeugen.

5 22. Vorrichtung nach einem der Ansprüche 18 bis 21, bei der die Rotoren (570) elliptisch erzeugte Querschnitte haben, deren Hauptachse sich in der Drehrichtung erstreckt.

23. Vorrichtung nach einem der Ansprüche 18 bis 21, bei der die Mischzone ein ringförmiger Raum (568) ist, in der die Innenfläche des Raumes (568) einen Radius von wenigstens der Hälfte des Radius der Außenfläche des Raumes (568) hat.

10 24. Vorrichtung nach einem der Ansprüche 18 bis 23, bei der der hintere Rand (573) einen Krümmungsradius im Bereich zwischen 0,5 und 15 mm hat.

25. Vorrichtung nach einem der Ansprüche 18 bis 21, bei der der hintere Rand (573') eine Rille (573) aufweist, die sich in Längsrichtung des genannten hinteren Randes (573') erstreckt.

15 26. Vorrichtung nach einem der Ansprüche 18 bis 21, bei der die Rotoren (570) nach außen verjüngt sind.

27. Vorrichtung nach Anspruch 18 oder 21, weiterhin enthaltend mehrere Statoren (580), die sich in die Mischzone von dem Gehäuse (551) erstrecken, wobei wenigstens einige der Statoren (580) einen ersten Kanal (582) aufweisen, der sich von außerhalb der Mischzone in Längsrichtung durch den Stator (580) erstreckt, sowie einen zweiten Kanal, der den ersten Kanal (582) mit der Mischzone verbindet, und ein Rückschlagventil (590) in dem zweiten Kanal.

20 28. Vorrichtung nach Anspruch 18, weiterhin enthaltend einen Speichertank (110'); eine Einrichtung (93'') zum Transportieren der Pulpe zu dem Speichertank (110'); vor dem Speichertank (110') eine Einrichtung (105) zum Zuführen von Alkali zu der Pulpe, eine Einrichtung (109) zum Zuführen von Sauerstoff zu der Pulpe und eine Einrichtung (108) zum Mischen des Sauerstoffs mit der Pulpe; wobei die Mischeinrichtung (108) die Mischzone aufweist.

25 29. Vorrichtung nach Anspruch 28, weiterhin enthaltend ein Ventil in der Transporteinrichtung (93'') zwischen der Mischeinrichtung (308) und dem Speichertank (110').

30 30. Vorrichtung nach einem der Ansprüche 28 und 29, weiterhin enthaltend eine Einrichtung zum Erwärmen der Pulpe vor der Mischeinrichtung (420), so daß sie in der Mischeinrichtung (420) auf einer Temperatur im Bereich von etwa 65°C bis etwa 121°C ist.

35 31. Vorrichtung nach Anspruch 18, enthaltend eine Pulpenextraktionsstufe, in der die Aufschlammung eine Pulpe ist, enthaltend eine Einrichtung (201') zum Einstellen der Konsistenz der Pulpe auf 7% bis 15%; einen Speichertank (213'); eine Einrichtung (209') zum Transportieren der Pulpe von der Konsistenzeinrichtung (201') zu dem Speichertank (213'); eine Einrichtung (221') hinter dem Tank (213') zum Waschen der Pulpe; eine Einrichtung (207') vor dem Tank (213') zum Zuführen von Alkali zu der Pulpe; eine Einrichtung (206') zwischen der Konsistenzeinrichtung (201') und dem Tank (213') zum Erwärmen der Pulpe; zwischen der Erwärmungseinrichtung (206') und dem Speichertank (213') eine Einrichtung (212) zum Zuführen von Sauerstoff zu der Pulpe und eine Einrichtung (211) zum Mischen des Sauerstoffs mit der Pulpe, wobei die Mischeinrichtung (211) die Mischzone aufweist.

40 32. Vorrichtung nach Anspruch 18 zur Erzeugung von inniger Berührung zwischen der Aufschlammung und Sauerstoff, wobei die Aufschlammung eine Pulpe einer Konsistenz von 7% bis 15%, und zum Behandeln der Pulpe mit dem Sauerstoff, weiterhin enthaltend eine Einrichtung (91') zum Waschen der Pulpe; eine Einrichtung (73') zum Transportieren der Pulpe zu der Wascheinrichtung (91'); vor der Wascheinrichtung (91') eine Einrichtung (85) zum Zuführen von Alkali zu der Pulpe; eine Einrichtung (87) zum Zuführen von Sauerstoff zu der Pulpe und eine Einrichtung (88) zum Mischen des Sauerstoffs mit der Pulpe, wobei die Mischeinrichtung (88) die Mischzone enthält.

50 33. Vorrichtung nach Anspruch 18, bei der die Aufschlammung eine Pulpenaufschlammung ist, enthaltend:

eine Einrichtung (425) zum Zuführen einer pH-Einstellchemikalie zur Pulpe,
eine Einrichtung (429) hinter der Chemikalien-Zuführeinrichtung zum Zuführen von Sauerstoff zur Pulpe,

55 einen Mischer (428) zum Mischen des Sauerstoffs mit der Pulpe,
einen Wascher (161') hinter dem Mischer (428) zum Waschen der sauerstoffbehandelten Pulpe,
eine Einrichtung (151') hinter dem Wascher (161') zum Zuführen einer Chemikalie, die aus der Gruppe ausgewählt ist, die aus Chlor, Chlordioxid, einer Kombination aus Chlor, Chlordioxid, Hypochlorid, Peroxid und Ozon besteht, zur Pulpe,

60 einen zweiten Mischer (438) zum Mischen der letztgenannten Chemikalien mit der Pulpe,
einen zweiten Wascher (201') hinter dem zweiten Mischer (438) zum Waschen der Pulpe,
eine Einrichtung (227') hinter dem zweiten Wascher (201') zum Hinzufügen einer pH-Einstellchemikalie zu der Pulpe,

eine Einrichtung (212') hinter der zweiten Chemikalien-Zuführeinrichtung (227') zum Zuführen von Sauerstoff zu der Pulpe,

65 einen dritten Mischer (211') zum Mischen des Sauerstoffs mit der Pulpe,

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eine Einrichtung (123', 141', 163', 183', 195'', 203'', 209'') zum Transportieren der Pulpe durch die obengenannten Einrichtungen,

wobei jeder der Mischer die genannte Mischzone aufweist.

34. Vorrichtung nach Anspruch 18, bei der die Aufschlammung eine Pulpenaufschlammung ist, weiterhin enthaltend:

einen Durchlaufkocher (14') zum fortlaufenden Kochen von Holzschnitzeln zur Bildung von Entlignifizierungsprodukten und ligninfreien Holzschnitzeln, und

einen Wascher (15'', 16''), der dem Kocher zugeordnet ist, um wenigstens einen Teil der Entlignifizierungsprodukte abzuziehen,

wobei der Kocher (14') ein Druckablaßventil zur Bildung von Holzpulpe aus den ligninfreien Holzschnitzeln durch teilweises Ablassen des Drucks von den Holzschnitzeln aufweist, einen Speichertank (22'),

ein Rohr (17'', 21'') zum Transportieren der die Holzpulpe und die übrigen Entlignifizierungsprodukte enthaltenden Aufschlammung unter Druck von dem Kocher (14'') zu einem Speichertank (22''),

eine Einrichtung (25') von dem Speichertank (22'') zum Zuführen einer pH-Einstellchemikalie zu der Aufschlammung,

eine Einrichtung (27') zwischen der pH-Einstellchemikalien-Zuführeinrichtung (25') und dem Speichertank (22'') zum Zuführen von Sauerstoff zu der Aufschlammung und

einer Mischer (116) vor dem Speichertank (22'') zum Mischen des Sauerstoffs mit der Aufschlammung, wobei der Mischer (116) die Mischzone aufweist.

35. Vorrichtung nach Anspruch 18, bei der die Aufschlammung eine Pulpenaufschlammung ist, weiterhin enthaltend:

einen Durchlaufkocher (14'') zum kontinuierlichen Kochen von Holzschnitzeln zur Bildung von Entlignifizierungsprodukten und ligninfreien Holzschnitzeln,

und einen Wascher (15'', 16''), der dem Kocher zugeordnet ist, um wenigstens einen Teil der Entlignifizierungsprodukte abzuziehen,

wobei der Kocher (14'') ein Druckablaßventil zur Bildung von Holzpulpe aus den ligninfreien Holzschnitzeln durch teilweises Ablassen des Drucks von den Holzschnitzeln aufweist,

einen Diffusionswascher,

eine Rohrleitung (17'', 21'') zum Transportieren der die Holzpulpe und die übrigen Entlignifizierungsprodukte enthaltenden Aufschlammung unter Druck aus dem Kocher (14'') zu einem Diffusionswascher,

eine Einrichtung (25) vor dem Diffusionswascher zum Zuführen einer pH-Einstell-Chemikalie zu der Aufschlammung,

eine Einrichtung (27') zwischen der pH-Einstell-Chemikalien-Zuführeinrichtung (25') und dem Speichertank (22') zum Zuführen von Sauerstoff zu der Aufschlammung und

einen Mischer (116) vor dem Diffusionswascher zum Mischen des Sauerstoffs mit der Aufschlammung, wobei der Mischer (116) die Mischzone aufweist.

40 Revendications

1. Procédé pour mélanger une pâte à papier d'une consistance de 7% à 15% à une substance chimique choisie dans le groupe constitué par des gaz non condensables dans ladite pâte à papier, des gaz non saturés et de la vapeur fortement surchauffée, comprenant l'opération consistant à:

—faire passer ladite substance chimique vers ladite pâte à papier dans une zone de mélange, et mélanger ladite substance chimique à ladite pâte à papier dans ladite zone de mélange, ladite zone de mélange ayant une série d'organes rotatifs traversant ladite pâte à papier et ayant un axe principal s'étendant dans la direction de rotation et ayant des bords d'attaque et de fuite, caractérisé en ce que:

—lesdits organes rotatifs traversent ladite pâte à papier dans une direction transversale à la direction de déplacement de ladite pâte à papier,

—lesdits organes rotatifs fournissent une superficie balayée dans ladite pâte à papier de 1000 à 1 000 000 m²/t de pâte à papier séchée en étuve, ladite superficie balayée étant la superficie balayée par les organes rotatifs dans une certaine quantité de pâte à papier au cours de son passage au travers de ladite zone de mélange, et étant définie par la relation:

$$A = \frac{F \cdot R \cdot N}{V}$$

dans laquelle:

A= superficie balayée par tonne de pâte à papier,

F= superficie balayée par un organe rotatif lorsqu'il effectue une rotation,

N= nombre d'organes rotatifs,

V= quantité pondérale de pâte à papier passant par ladite zone de mélange,

R= nombre de tours des organes rotatifs dans ladite quantité pondérale de pâte à papier,

ledit bord d'attaque ayant un rayon de courbure dans l'intervalle de 0,5 à 15 mm.

2. Procédé selon la revendication 1, dans lequel ladite superficie balayée est de 14 100 à 1 000 000 m²/t de pâte à papier séchée en étuve.
3. Procédé selon la revendication 1, dans lequel ladite superficie balayée est de 25 000 à 150 000 m²/t de pâte à papier séchée en étuve.
- 5 4. Procédé selon la revendication 1, dans lequel ladite superficie balayée est d'environ 65 400 m²/t de pâte à papier séchée en étuve.
5. Procédé selon l'une quelconque des revendications précédentes, dans lequel ledit bord de fuite à un rayon de courbure dans l'intervalle de 0,5 à 15 mm.
- 10 6. Procédé selon l'une quelconque des revendications précédentes, dans lequel ladite substance chimique est ajoutée progressivement à ladite pâte à papier.
7. Procédé selon l'une quelconque des revendications 1 à 5, dans lequel ledit mélange s'effectue sous une pression allant jusqu'à 830 kPa au manomètre.
- 15 8. Procédé selon l'une quelconque des revendications précédentes, dans lequel ladite substance chimique est sélectionnée dans le groupe constitué par l'oxygène, l'ozone, l'air, le chlore, le dioxyde de chlore, le dioxyde de soufre, l'ammoniaque, l'azote, le dioxyde de carbone, le chlorure d'hydrogène, l'oxyde nitrique et le peroxyde d'azote.
9. Procédé selon la revendication 8, caractérisé en ce qu'il comprend les opérations consistant à mélanger intimement ladite oxygène à ladite pâte à papier, ledit mélange se produisant dans ladite zone de mélange, à transporter ladite pâte à papier vers un réservoir de stockage et à stocker ladite pâte à papier dans ledit réservoir de stockage.
- 20 10. Procédé selon la revendication 9, dans lequel la quantité d'oxygène ajoutée à ladite pâte à papier est de 5 à 50 kg/t de pâte à papier séchée en étuve.
11. Procédé selon les revendications 9 ou 10, dans lequel ledit mélange dudit oxygène s'effectue en moins d'une minute.
- 25 12. Procédé selon la revendication 9, caractérisé en ce qu'il comprend en outre, avant ladite opération de mélange, l'opération consistant à chauffer ladite pâte à papier de façon à ce qu'elle soit à une température dans l'intervalle d'environ 65°C à environ 121°C au cours de ladite opération de mélange.
13. Procédé selon la revendication 8, dans lequel un contact intime est créé entre ladite pâte à papier de bois et en ce que ladite pâte à papier est traitée avec ledit oxygène, l'opération comprenant ajouter de l'oxygène à ladite pâte à papier, mélanger ledit oxygène à ladite pâte à papier, ledit mélange se produisant dans ladite zone de mélange, transporter ladite pâte à papier vers une pile laveuse, et laver ladite pâte à papier dans ladite pile laveuse.
- 30 14. Procédé selon la revendication 9, dans lequel un alcali est ajouté à ladite pâte à papier, dans une proportion exprimée en hydroxyde de sodium, allant de 0,5% à 7%, sur la base du poids sec à l'étuve de ladite pâte à papier, et à chauffer ladite pâte à papier avant d'ajouter ledit oxygène à ladite pâte à papier, et de mélanger intimement la pâte à papier à celui-ci, dans lequel ladite pâte à papier traitée est stockée dans ledit réservoir de stockage pendant un temps allant de 0,5 à 4 heures, et dans lequel, après ledit stockage, les sous-produits d'extraction provenant de ladite pâte à papier sont lavés.
- 40 15. Procédé selon la revendication 8, comprenant l'opération consistant à traiter ladite pâte à papier avec de l'oxygène avec un pH alcalin et à une température d'environ 65°C à environ 121°C, à laver ladite pâte à papier traitée à l'oxygène, à traiter ladite pâte à papier lavée avec un agent de blanchiment sélectionné dans un groupe constitué par le chlore, le dioxyde de chlore, des combinaisons de chlore et de dioxyde de chlore, des hypochlorites, des peroxydes, de l'ozone, à laver ladite pâte à papier traitée avec un agent de blanchiment et à traiter cette pâte à papier venant d'être lavée à une consistance de 7% à 15% à l'oxygène, avec un pH alcalin et à une température d'environ 65°C à environ 121°C, ledit oxygène utilisé dans chacun desdits traitements à l'oxygène étant mélangé à ladite pâte à papier dans l'une desdites zones de mélange.
- 45 16. Procédé selon la revendication 8, comprenant en outre l'opération consistant à préparer ladite pâte à papier en mettant en digestion continue des copeaux de bois par des substances chimiques, à la chaleur et sous pression, pour préparer des produits de délignification et des copeaux de bois délignifiés, à éliminer au moins une partie desdits produits de délignification, à préparer ladite pâte à papier à partir des copeaux de bois délignifiés en relâchant partiellement la pression appliquée auxdits copeaux de bois, à transporter une bouillie contenant ladite pâte à papier de bois et les produits de délignification restants sous pression vers un réservoir de stockage, et à stocker ladite bouillie dans ledit réservoir, à ajuster, avant ledit stockage, le pH de ladite bouillie à une valeur dans l'intervalle de 8 à 14, à ajouter, entre ledit ajustement du pH et ledit stockage, ledit oxygène à ladite bouillie, à mélanger, entre ledit ajustement du pH et ledit stockage, ledit oxygène à ladite bouillie dans ladite zone de mélange.
- 50 17. Procédé selon la revendication 8, comprenant en outre l'opération consistant à préparer ladite pâte à papier en mettant en digestion continue des copeaux de bois avec des substances chimiques, à la chaleur et sous pression, afin de préparer des produits de délignification et des copeaux de bois délignifiés, à éliminer au moins une partie desdits produits de délignification, à préparer ladite pâte à papier à partir desdits copeaux de bois délignifiés en relâchant partiellement la pression appliquée auxdits copeaux de bois, à transporter une bouillie contenant ladite pâte à papier et les produits de délignification restants sous pression vers une pile laveuse à diffusion, à laver ladite pâte à papier dans ladite pile laveuse à diffusion, à ajuster, avant ledit lavage par diffusion, le pH de ladite bouillie à une valeur dans l'intervalle de 8 à 14, à
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ajouter, entre ledit ajustement du pH et ledit lavage par diffusion, de l'oxygène à ladite bouillie, à mélanger, entre ledit ajustement du pH et ledit lavage par diffusion, ledit oxygène à ladite bouillie dans ladite zone de mélange.

18. Appareil pour mettre en oeuvre le procédé selon l'une quelconque des revendications précédentes, comprenant un boîtier, un orifice d'entrée et un orifice de sortie ménagés dans ledit boîtier, un arbre dans ledit boîtier, une zone de mélange dans ledit boîtier, caractérisé par:

une pluralité de rotors (570) sur ledit arbre (560) dans ladite zone de mélange, lesdits rotors (570) ayant des bords d'attaque et de fuite (572, 573), ledit bord d'attaque (572) ayant un rayon de courbure dans l'intervalle de 0,5 à 15 mm, lesdits rotors (570) pouvant tourner dans la bouillie dans une direction transversale à la direction de déplacement de ladite bouillie, et lesdits rotors (570) fournissant une superficie balayée de 10 000 à 1 000 000 m²/t de matière solide séchée à l'étuve dans l'adite bouillie, ladite superficie balayée étant telle que définie dans la revendication 1.

19. Appareil selon la revendication 18, dans lequel lesdits rotors (570) fournissent une superficie balayée de 14 100 à 1 000 000 m²/t de matière solide séchée à l'étuve dans ladite bouillie.

20. Appareil selon la revendication 18, dans lequel lesdits rotors (570) fournissent une superficie balayée de 25 000 à 150 000 m²/t de matière solide séchée à l'étuve dans ladite bouillie.

21. Appareil selon la revendication 16, dans lequel lesdits rotors (570) fournissent une superficie balayée d'environ 65 400 m²/t de matière solide séchée à l'étuve dans ladite bouillie.

22. Appareil selon l'une quelconque des revendications 18 à 21, dans lequel lesdits rotors (570) ont des sections droites elliptiques dont le grand axe s'étend dans la direction de rotation.

23. Appareil selon l'une quelconque des revendications 18 à 21, dans lequel ladite zone de mélange est un espace annulaire (568), la surface intérieure dudit espace (568) ayant un rayon au moins égal à la moitié du rayon de la surface extérieure dudit espace (568).

24. Appareil selon l'une quelconque des revendications 18 à 23, dans lequel le bord de fuite (573) a un rayon de courbure dans l'intervalle de 0,5 à 15 mm.

25. Appareil selon l'une quelconque des revendications 18 à 21, dans lequel le bord de fuite (573') présente une gorge (574) s'étendant dans le sens de la longueur dudit bord de fuite (573').

26. Appareil selon l'une quelconque des revendications 18 à 21, dans lequel lesdits rotors (570) sont effilés vers l'extérieur.

27. Appareil selon la revendication 18 ou 21, comprenant en outre une pluralité de stators (580) s'étendant dans ladite zone de mélange, à partir dudit boîtier (551), au moins certains desdits stators (580) ayant un premier passage (582) s'étendant depuis l'extérieur de ladite zone de mélange dans le sens de la longueur, au travers dudit stator (580) et un second passage communiquant entre ledit premier passage (582) et ladite zone de mélange, ainsi qu'un clapet de retenue (590) dans ledit second passage.

28. Appareil selon la revendication 18, comprenant en outre un réservoir de stockage (110'); un moyen (93') pour transporter ladite pâte à papier vers ledit réservoir de stockage (110'); avant ledit réservoir de stockage (110'), un moyen (105) pour ajouter un alcali à ladite pâte à papier, un moyen (109) pour ajouter de l'oxygène à ladite pâte à papier, et un moyen (108) pour mélanger ledit oxygène à ladite pâte à papier; ledit moyen de mélange (108) comportant ladite zone de mélange.

29. Appareil selon la revendication 28, comprenant en outre un clapet dans ledit moyen de transport (93') entre ledit moyen de mélange (108) et ledit réservoir de stockage (110').

30. Appareil selon l'une quelconque des revendications 28 et 29, comprenant en outre, avant ledit moyen de mélange (420), un moyen pour chauffer ladite pâte à papier de façon à ce qu'elle soit à une température dans l'intervalle d'environ 65°C environ 121°C dans ledit moyen de mélange (420).

31. Appareil selon la revendication 18, comprenant un étage d'extraction de pâte à papier dans lequel ladite bouillie est une pâte à papier, comprenant un moyen (201') pour ajuster la consistance de ladite pâte à papier à 7%—15%; un réservoir de stockage (213'); un moyen (209') pour transporter ladite pâte à papier depuis ledit moyen d'ajustement de la consistance (201') vers ledit réservoir de stockage (213'), un moyen (221'), après ledit réservoir (213') pour laver ladite pâte à papier; un moyen (207') avant ledit réservoir (213') pour ajouter un alcali à ladite pâte à papier; un moyen (206') entre ledit moyen d'ajustement de la consistance (201') et ledit réservoir (213') pour chauffer ladite pâte à papier; entre ledit moyen de chauffage (206') et ledit réservoir de stockage (213'), un moyen (212) pour ajouter de l'oxygène à ladite pâte à papier et un moyen (211) pour mélanger ledit oxygène à ladite pâte à papier, ledit moyen de mélange (211) comportant ladite zone de mélange.

32. Appareil selon la revendication 18 pour créer un contact intime entre ladite bouillie et l'oxygène, ladite bouillie étant une pâte à papier ayant une consistance de 7% à 15% et pour traiter ladite pâte à papier avec ledit oxygène, comprenant en outre un moyen (91') pour laver ladite pâte à papier; un moyen (73') pour transporter ladite pâte à papier vers ledit moyen de lavage (91'); avant ledit moyen de lavage (91'), un moyen (85) pour ajouter un alcali à ladite pâte à papier, un moyen (87) pour ajouter de l'oxygène à ladite pâte à papier, et un moyen (88) pour mélanger ledit oxygène à ladite pâte à papier, ledit moyen de mélange (88) comportant ladite zone de mélange.

33. Appareil selon la revendication 18, dans lequel ladite bouillie est une bouillie de pâte à papier, caractérisé en ce qu'il comprend:

un moyen (425) pour ajouter un agent d'ajustement du pH à la pâte à papier,

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un moyen (429), après ledit moyen d'addition d'un agent, pour ajouter de l'oxygène à ladite pâte à papier,

un mélangeur (428) pour mélanger ledit oxygène à ladite pâte à papier,

une pile laveuse (161'), après ledit mélangeur (428), pour laver ladite pâte à papier traitée à l'oxygène,

5 un moyen (151'), après ladite pile laveuse (161'), pour ajouter un agent sélectionné dans le groupe constitué par le chlore, le dioxyde de chlore, une combinaison de chlore et de dioxyde de chlore, un hypochlorite, un peroxyde, et l'ozone, à ladite pâte à papier,

un second mélangeur (438) pour mélanger ce dernier agent chimique à ladite pâte à papier,

une seconde pile laveuse (201'), après ledit second mélangeur (438), pour laver ladite pâte à papier,

10 un moyen (227'), après ladite seconde pile laveuse (201'), pour ajouter un agent d'ajustement du pH à ladite pâte à papier,

un moyen (212'), après ledit second moyen d'addition d'un agent chimique (227'), pour ajouter de l'oxygène à ladite pâte à papier,

un troisième mélangeur (211') pour mélanger ledit oxygène à ladite pâte à papier,

15 des moyens (123', 141', 163', 183', 195'', 203'', 209'') pour transporter ladite pâte à papier dans lesdits éléments mentionnés ci-dessus,

chacun desdits mélangeurs comportant ladite zone de mélange.

34. Appareil selon la revendication 18, dans lequel ladite bouillie est une bouillie de pâte à papier, caractérisé en ce qu'il comprend en outre:

20 un lessiveur continu (14'') pour mettre en digestion continue des copeaux de bois afin de former des produits de délignification et des copeaux de bois délignifiés, et

une pile laveuse (15'', 16'') associée audit lessiveur pour éliminer au moins une partie desdits produits de délignification,

25 ledit lessiveur (14'') ayant une soupape de sureté pour préparer de la pâte à papier de bois à partir desdits copeaux de bois délignifiés, en relâchant partiellement la pression appliquée auxdits copeaux de bois,

un réservoir de stockage (22'),

30 une canalisation (17'', 21'') pour transporter une bouillie contenant ladite pâte à papier de bois et des produits de délignification restants, sous pression entre ledit lessiveur (14'') et un réservoir de stockage (22''),

un moyen (25'), avant ledit réservoir de stockage (22'), pour ajouter un agent d'ajustement du pH à ladite bouillie,

un moyen (27'), entre ledit moyen d'addition d'un agent d'ajustement du pH (25') et ledit réservoir de stockage (22''), pour ajouter de l'oxygène à ladite bouillie et,

35 un mélangeur (116), avant ledit réservoir de stockage (22''), pour mélanger ledit oxygène à ladite bouillie, ledit mélangeur (116) comportant ladite zone de mélange.

35. Appareil selon la revendication 18, dans lequel ladite bouillie est une bouillie de pâte à papier, caractérisé en ce qu'il comprend en outre:

40 un lessiveur continu (14'') pour mettre en digestion continue des copeaux de bois afin de préparer des produits de délignification et des copeaux de bois délignifiés, et

une pile laveuse (15'', 16'') associée audit lessiveur pour éliminer au moins une partie desdits produits de délignification,

45 ledit lessiveur (14'') ayant une soupape de sûreté pour préparer de la pâte à papier de bois à partir desdits copeaux de bois délignifiés, par relâchement partiel de la pression appliquée auxdits copeaux de bois,

une pile laveuse à diffusion,

une canalisation (17'', 21'') pour transporter une bouillie contenant ladite pâte à papier de bois et les produits de délignification restants, sous pression entre ledit lessiveur (14'') et une pile laveuse à diffusion,

50 un moyen (25) avant ladite pile laveuse à diffusion, pour ajouter un agent d'ajustement du pH à ladite bouillie,

un moyen (27') entre ledit moyen d'addition d'un agent d'ajustement du pH (25') et ledit réservoir de stockage (22'') pour ajouter de l'oxygène à ladite bouillie, et

un mélangeur (116), avant ladite pile laveuse à diffusion, pour mélanger ledit oxygène à ladite bouillie, ledit mélangeur (116) comportant ladite zone de mélange.

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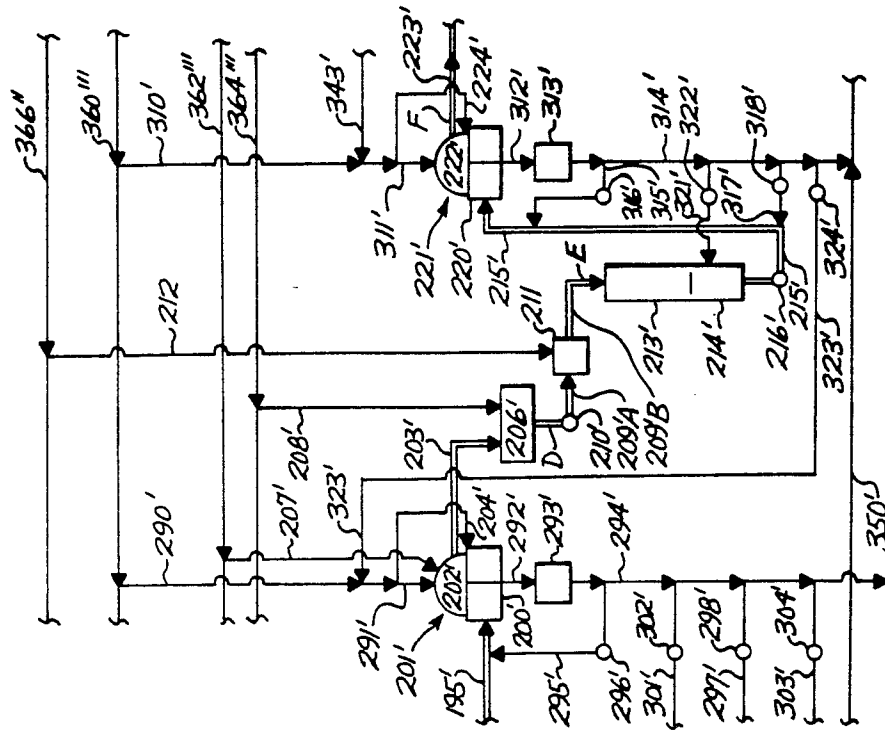


Fig. 2

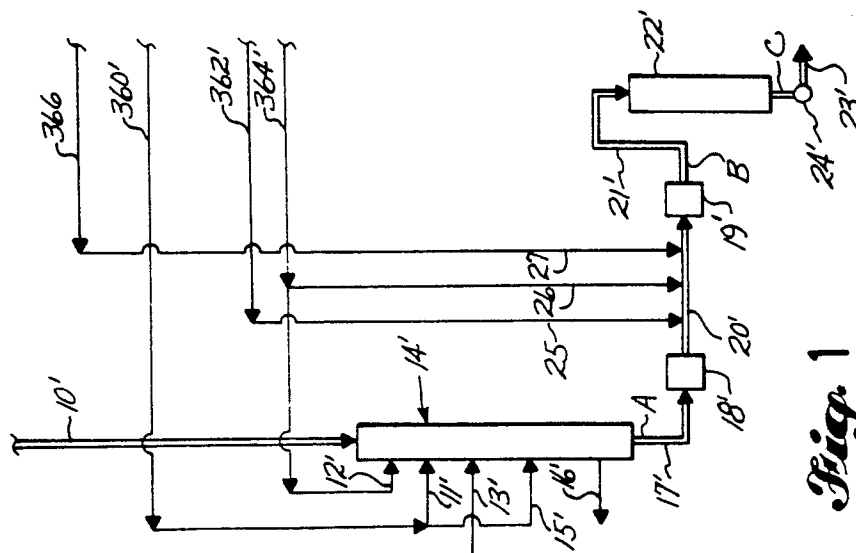


Fig. 1

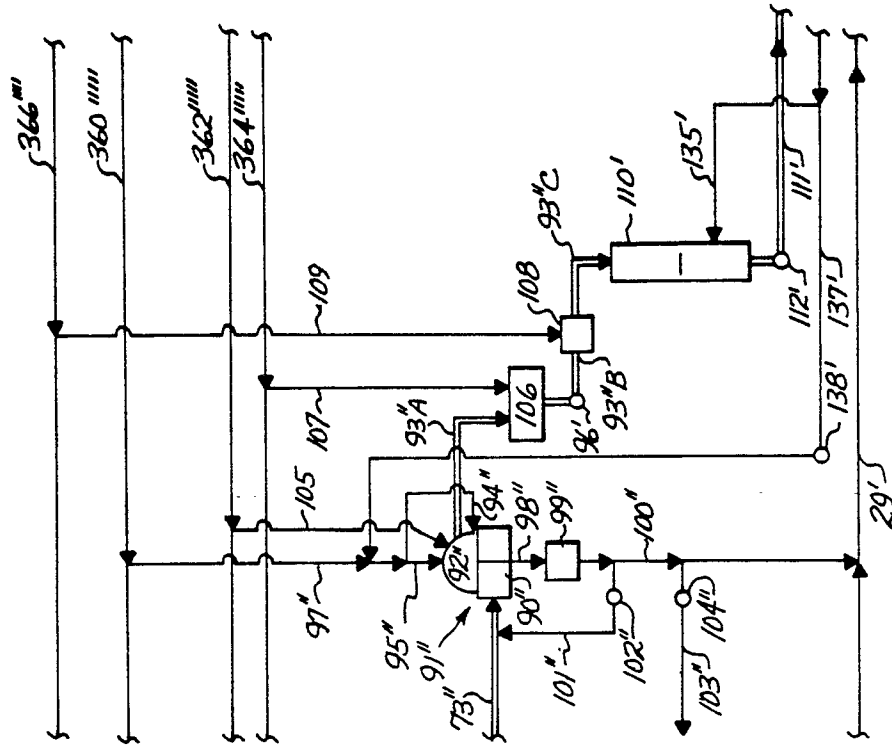


Fig. 4

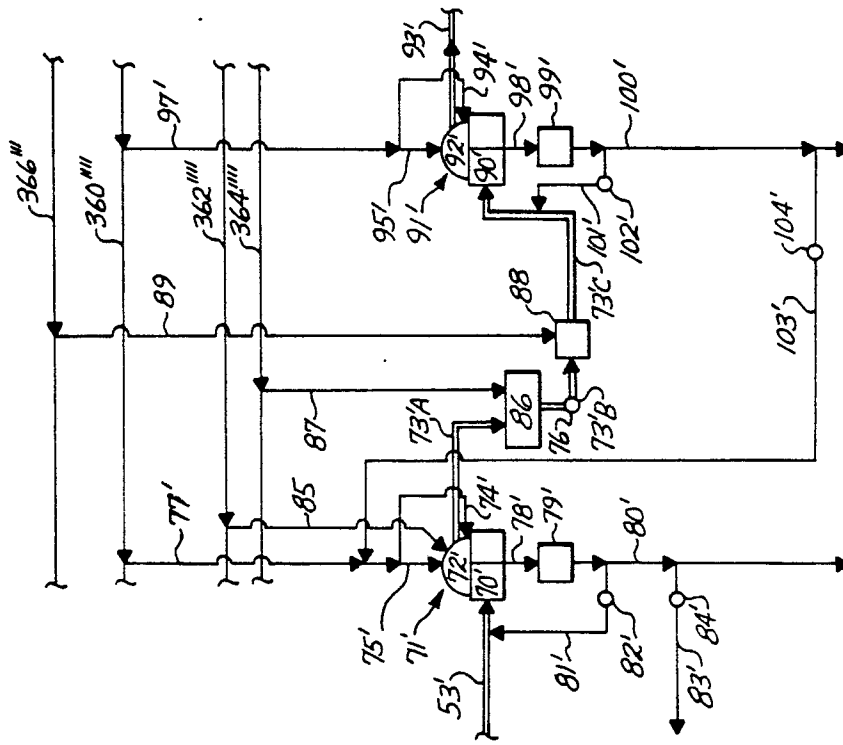


Fig. 3

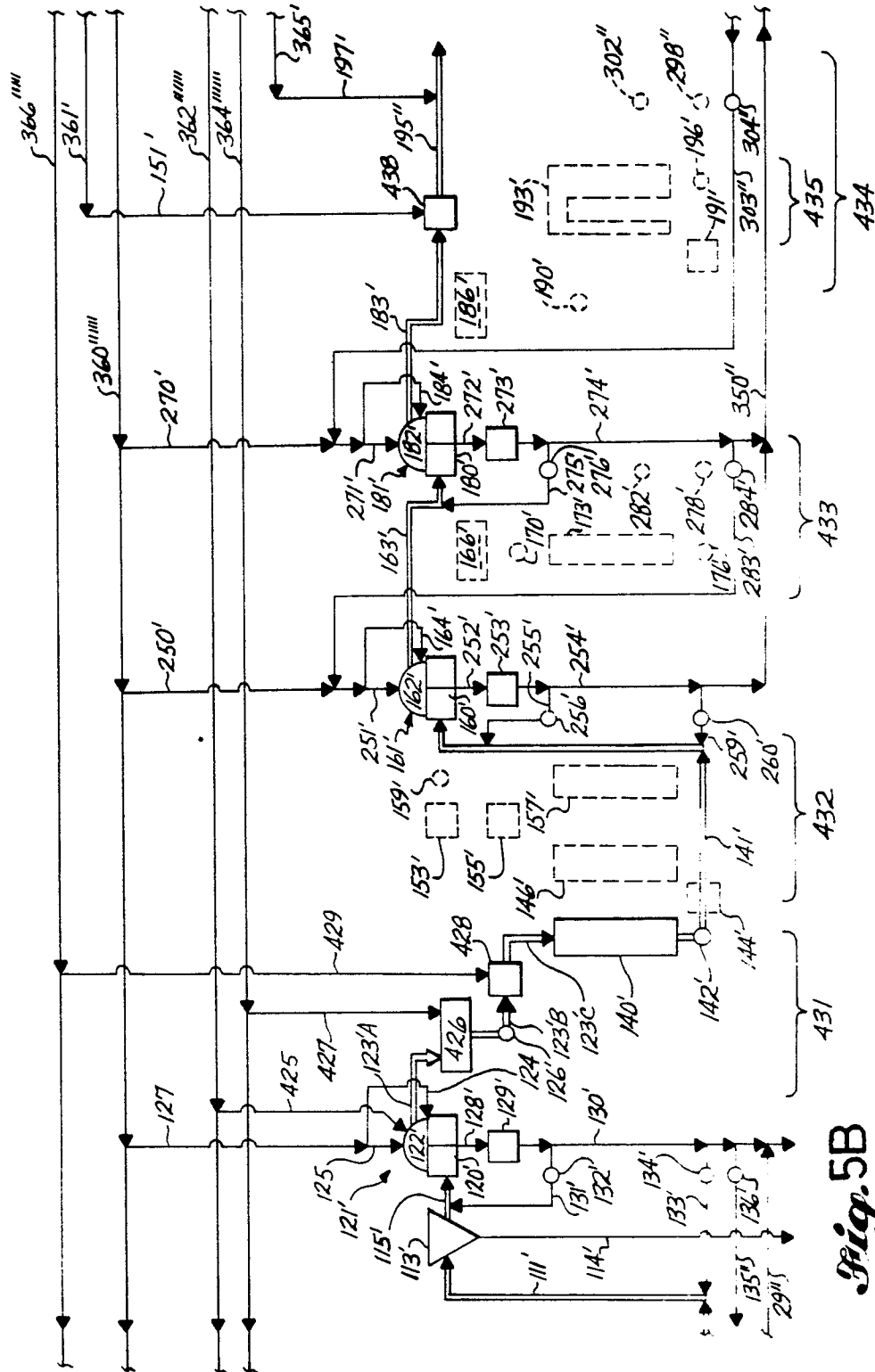


Fig. 5B

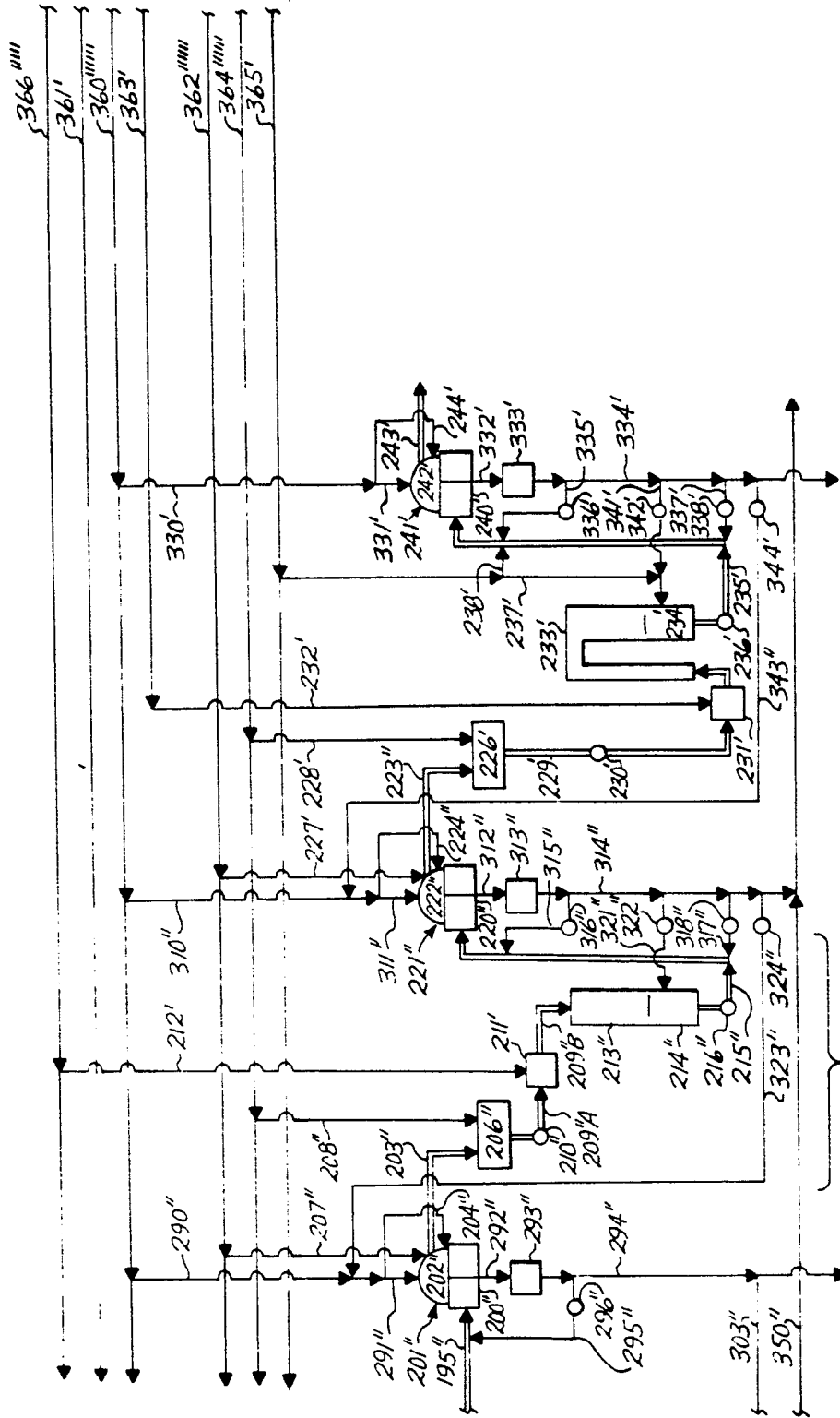


Fig. 5C

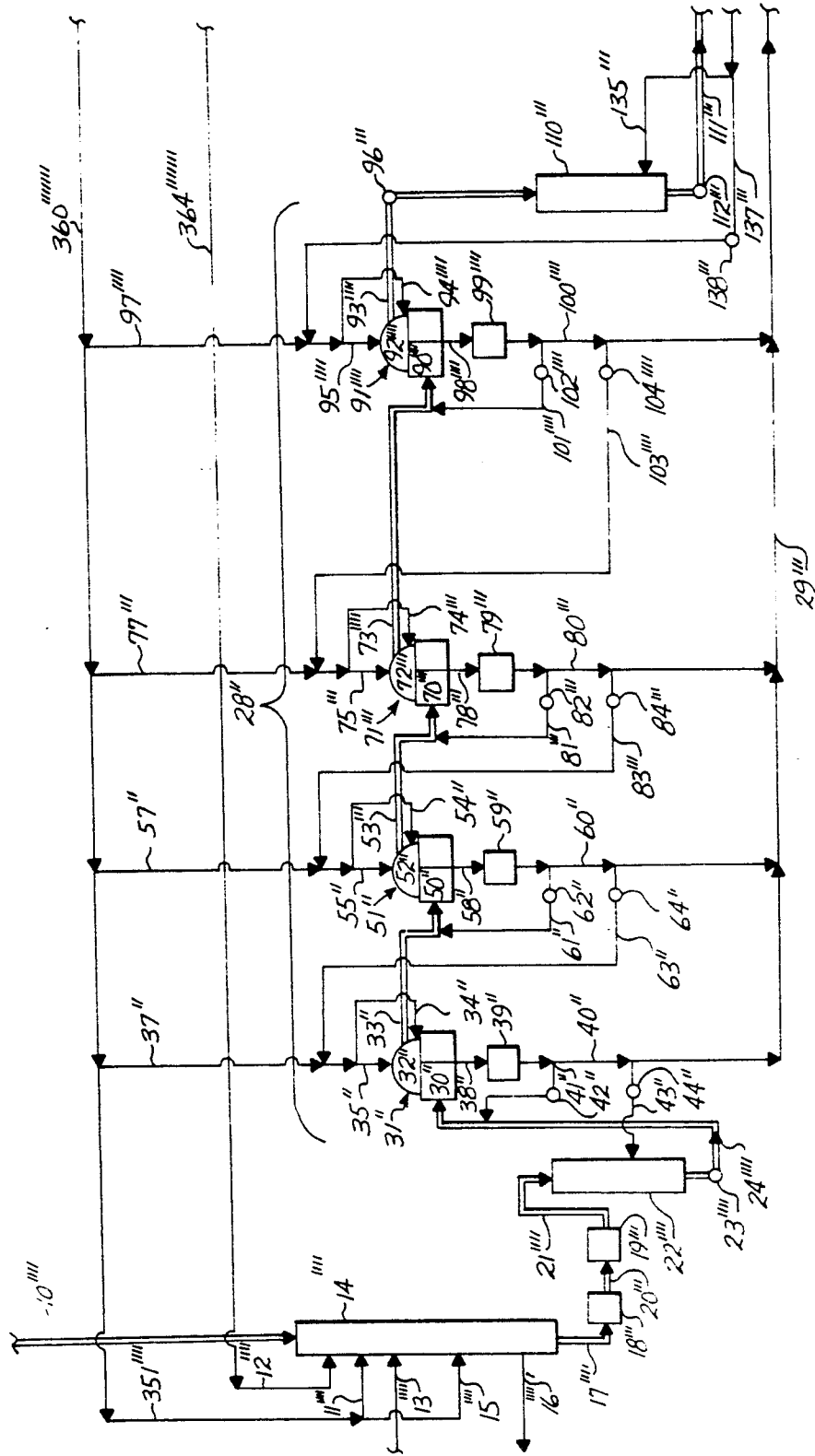
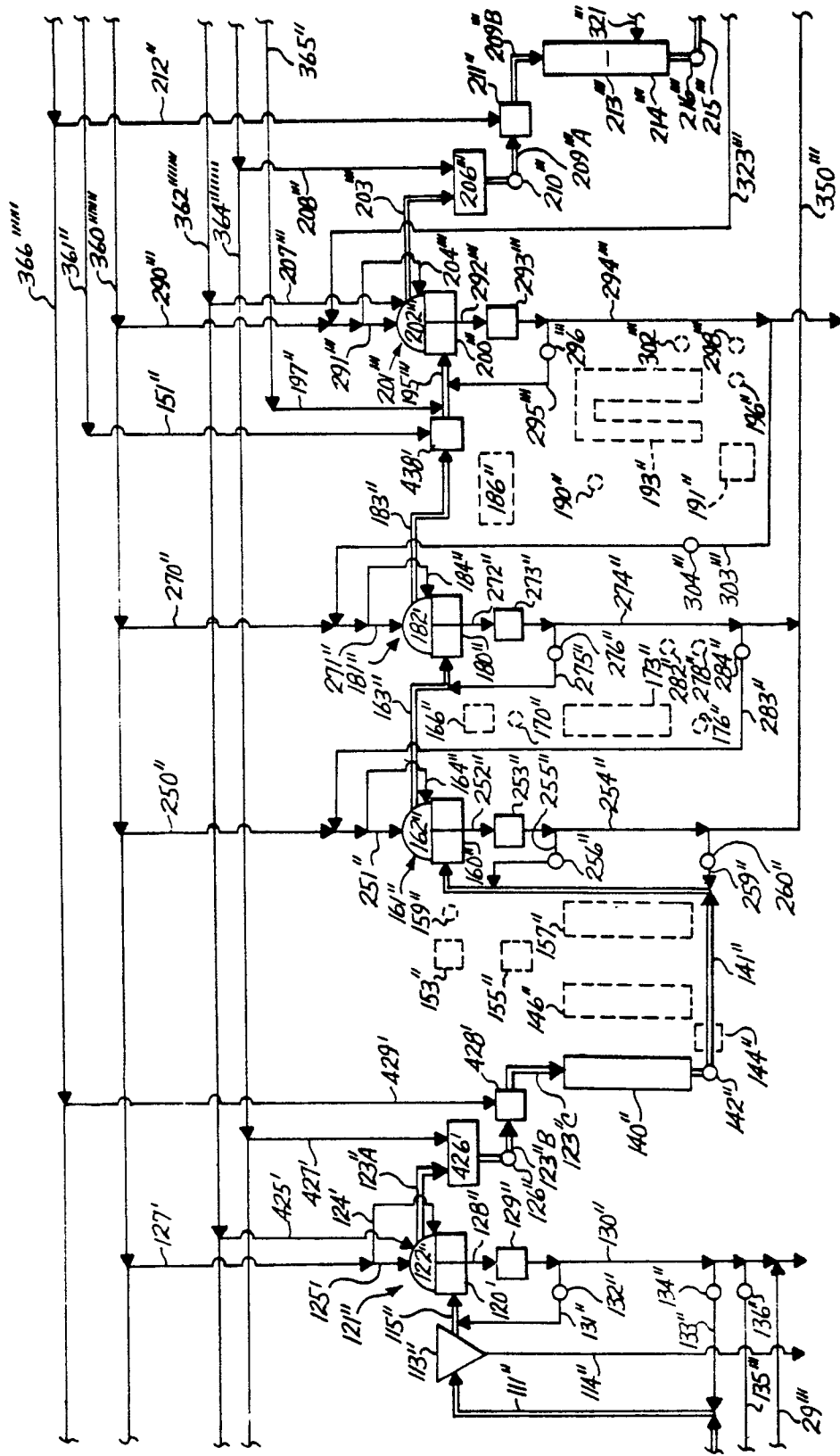


Fig. 6A



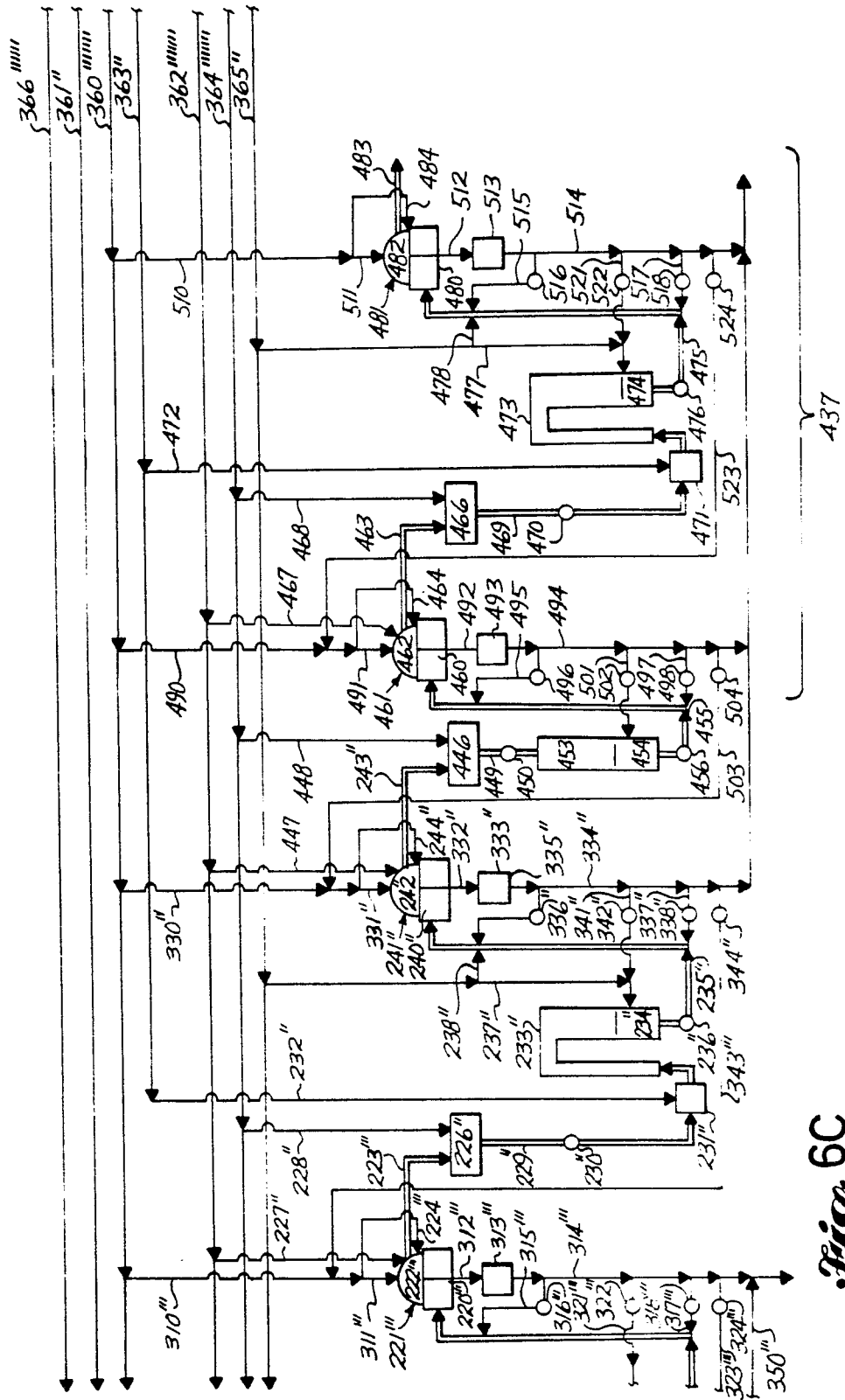


Fig. 6C

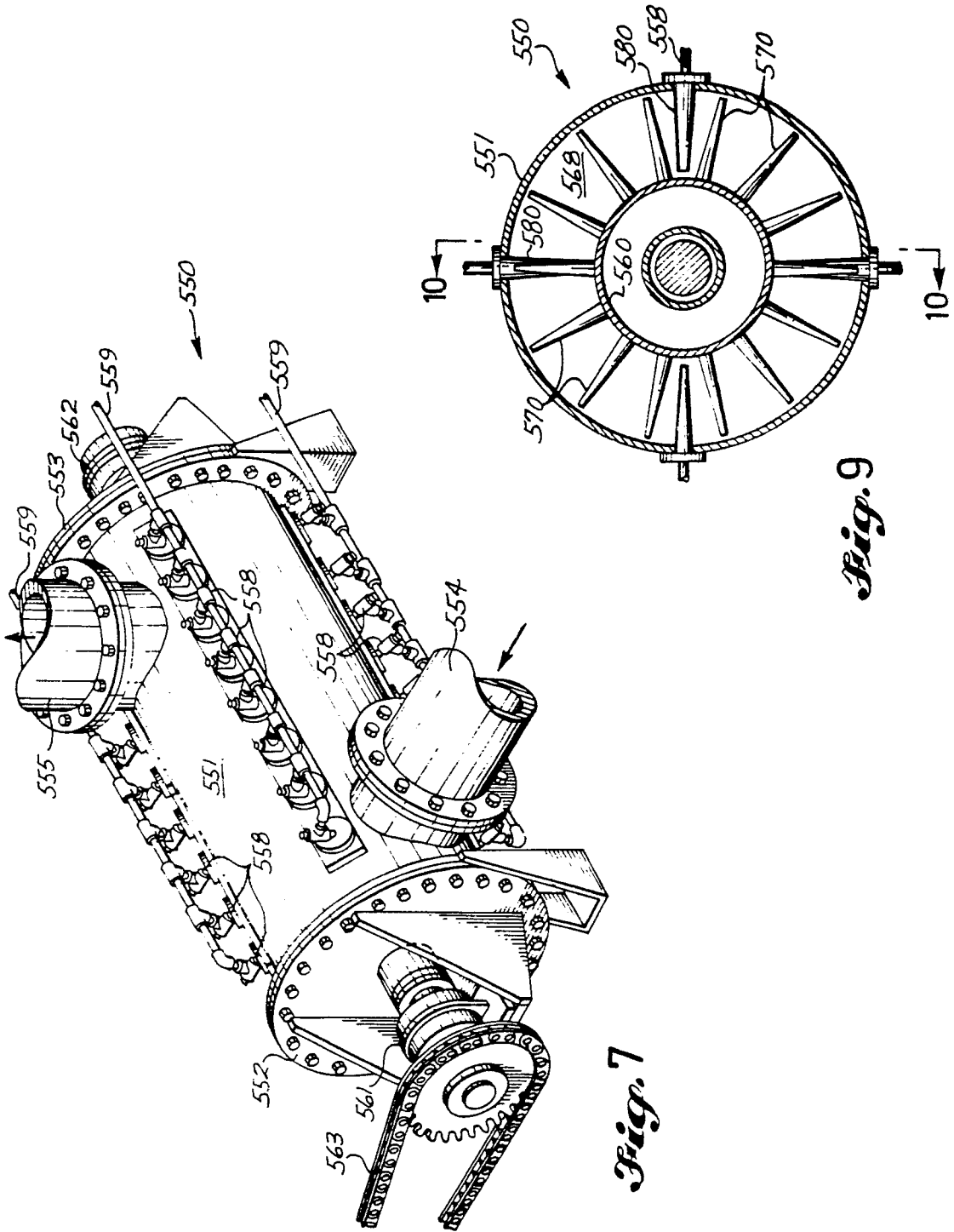


Fig. 7

Fig. 9

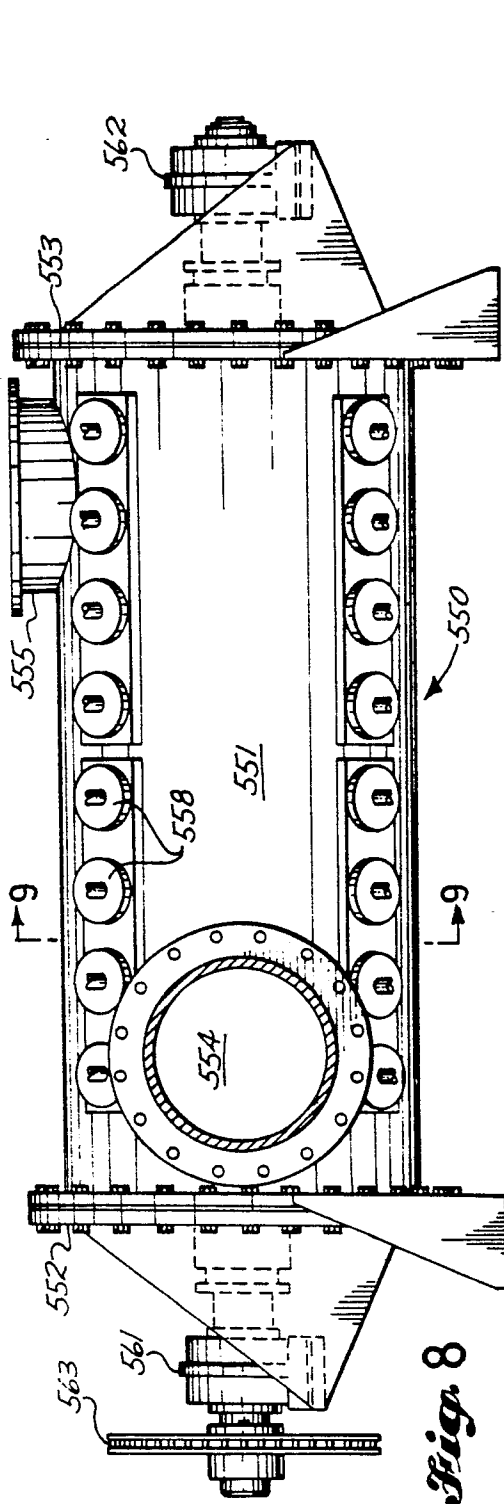


Fig. 8

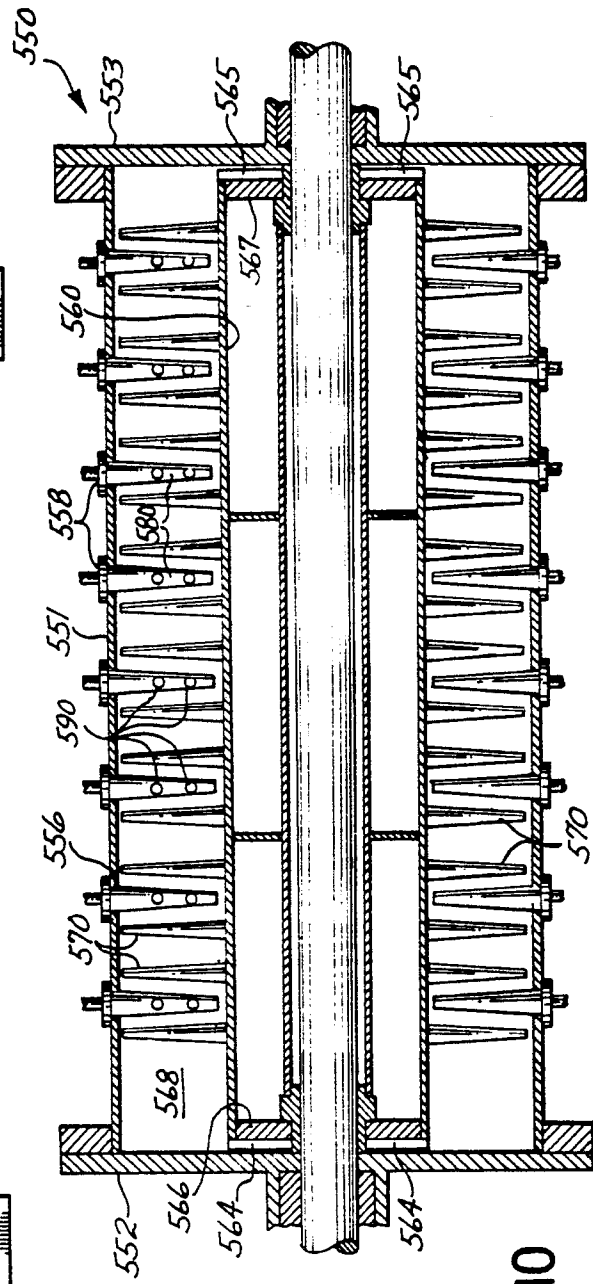
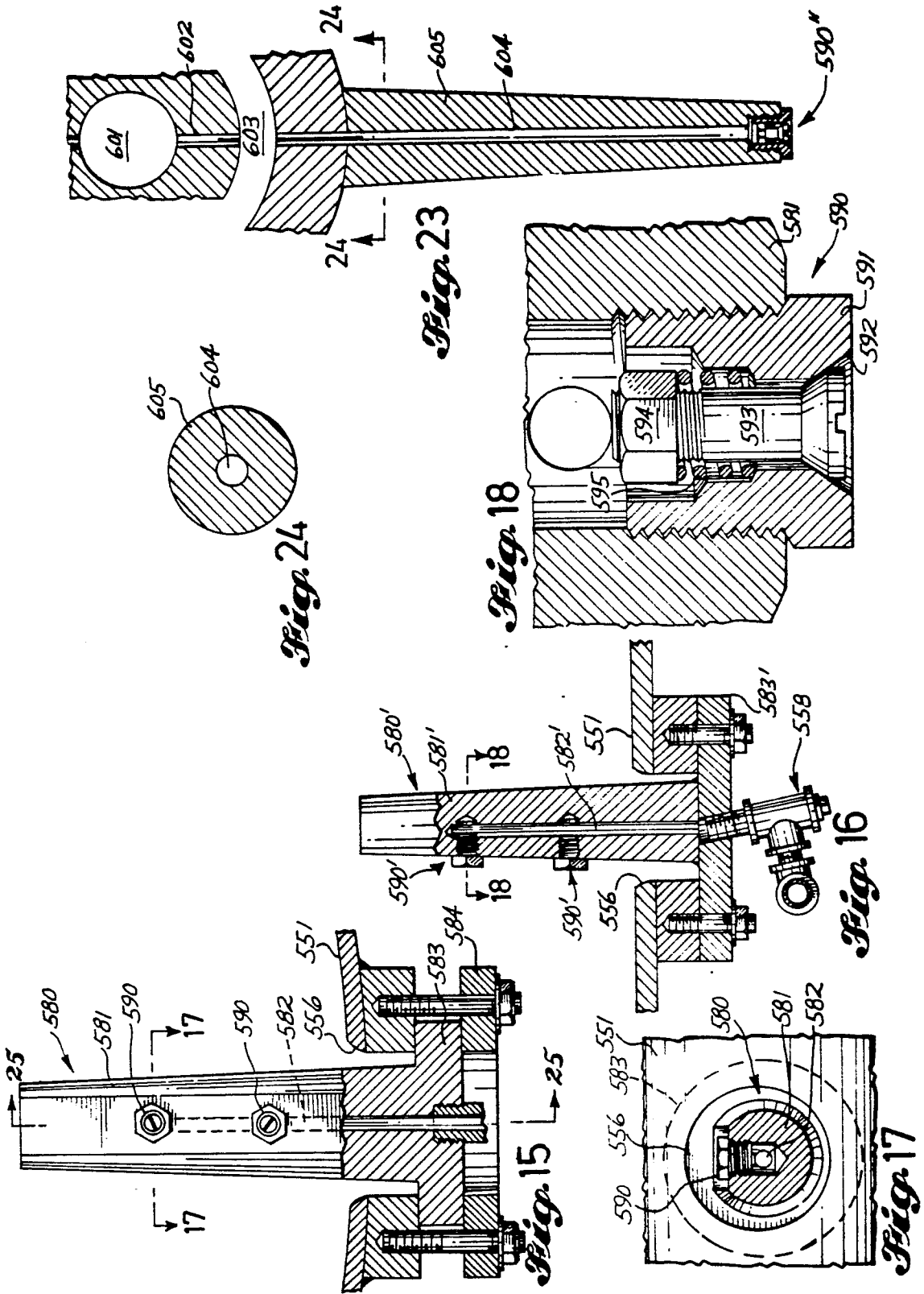


Fig. 10



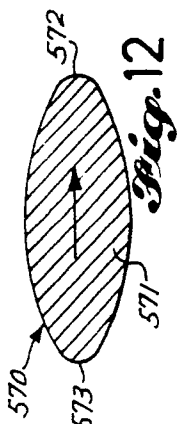


Fig. 12

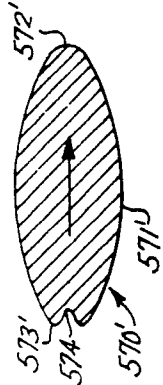


Fig. 14

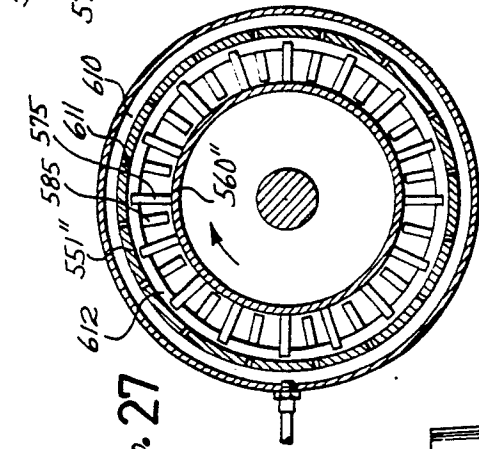


Fig. 27

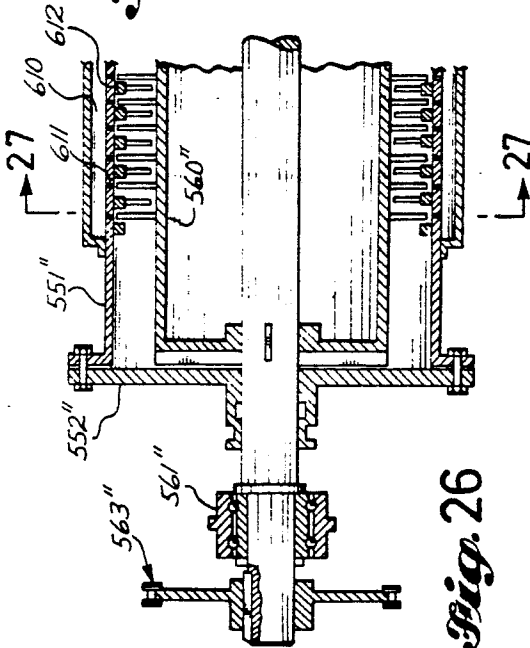


Fig. 26

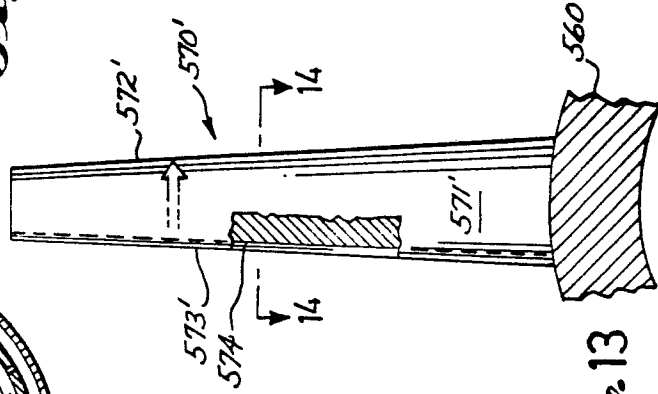


Fig. 13

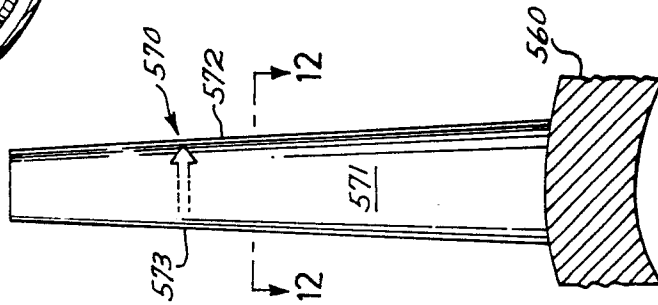


Fig. 11

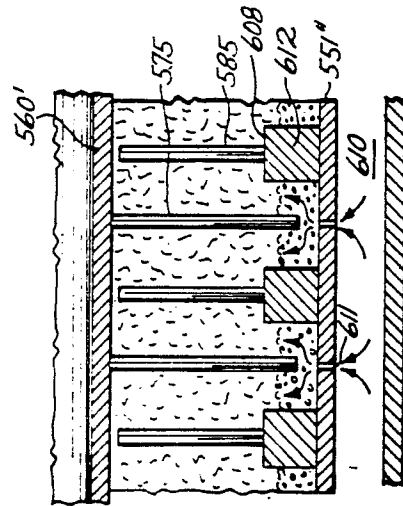


Fig. 28

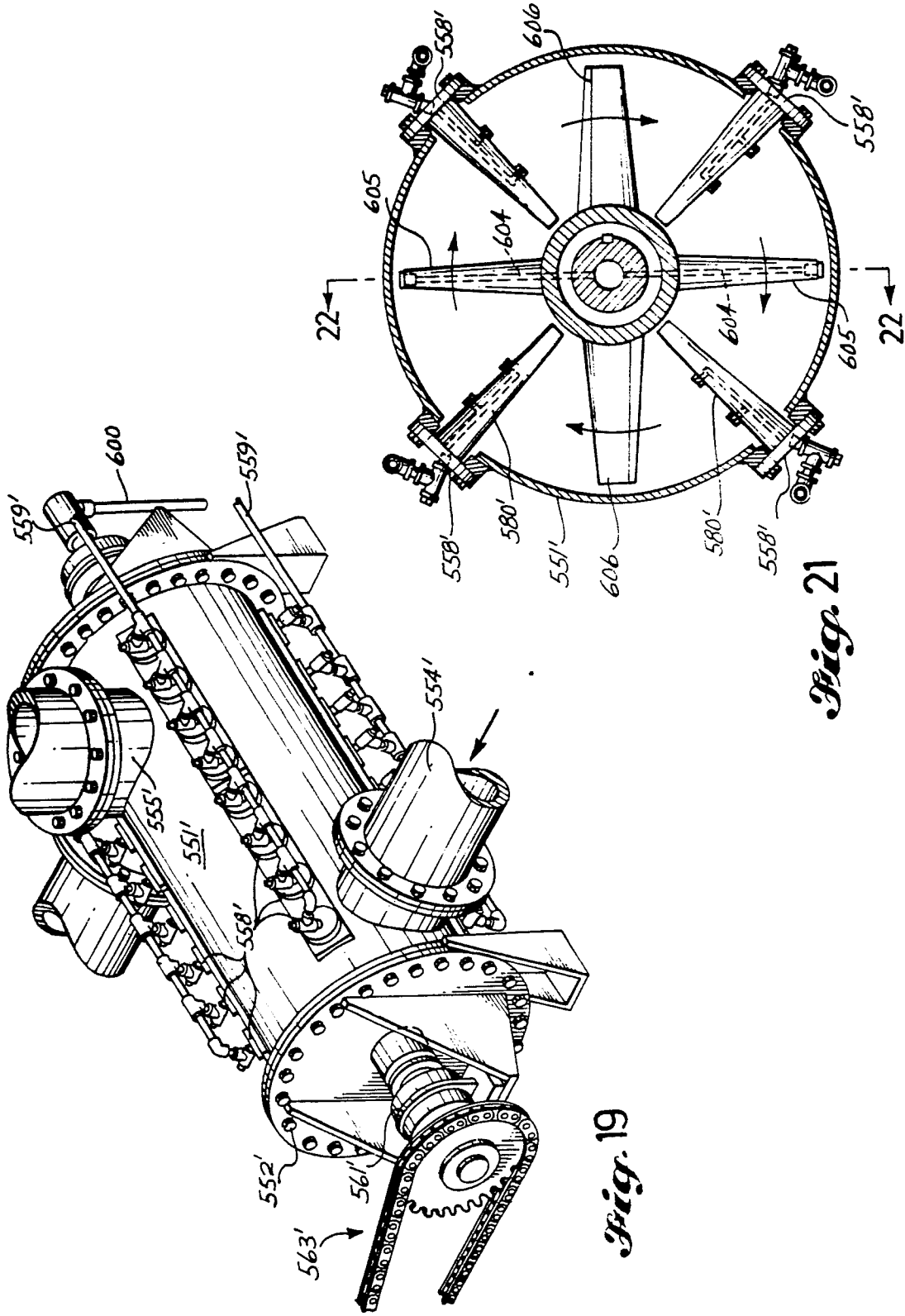


Fig. 21

Fig. 19

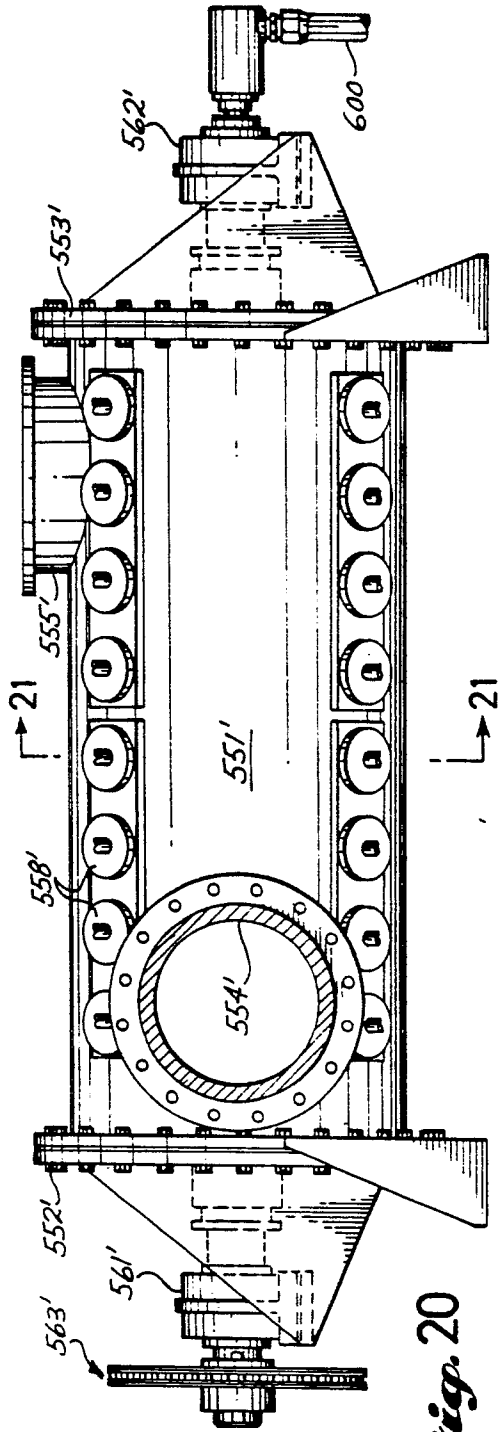


Fig. 20

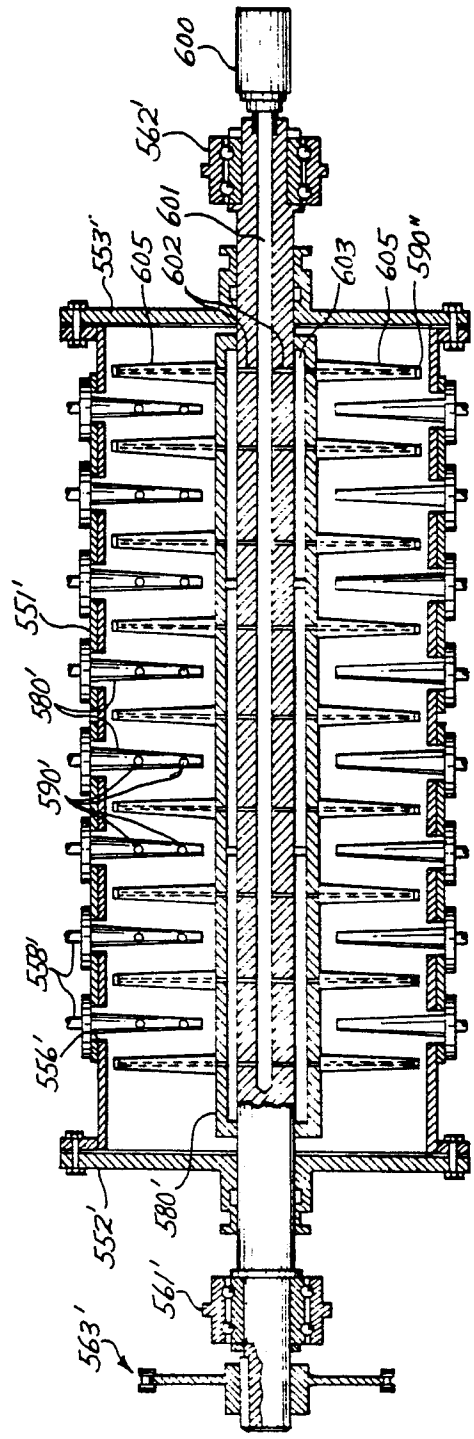


Fig. 22

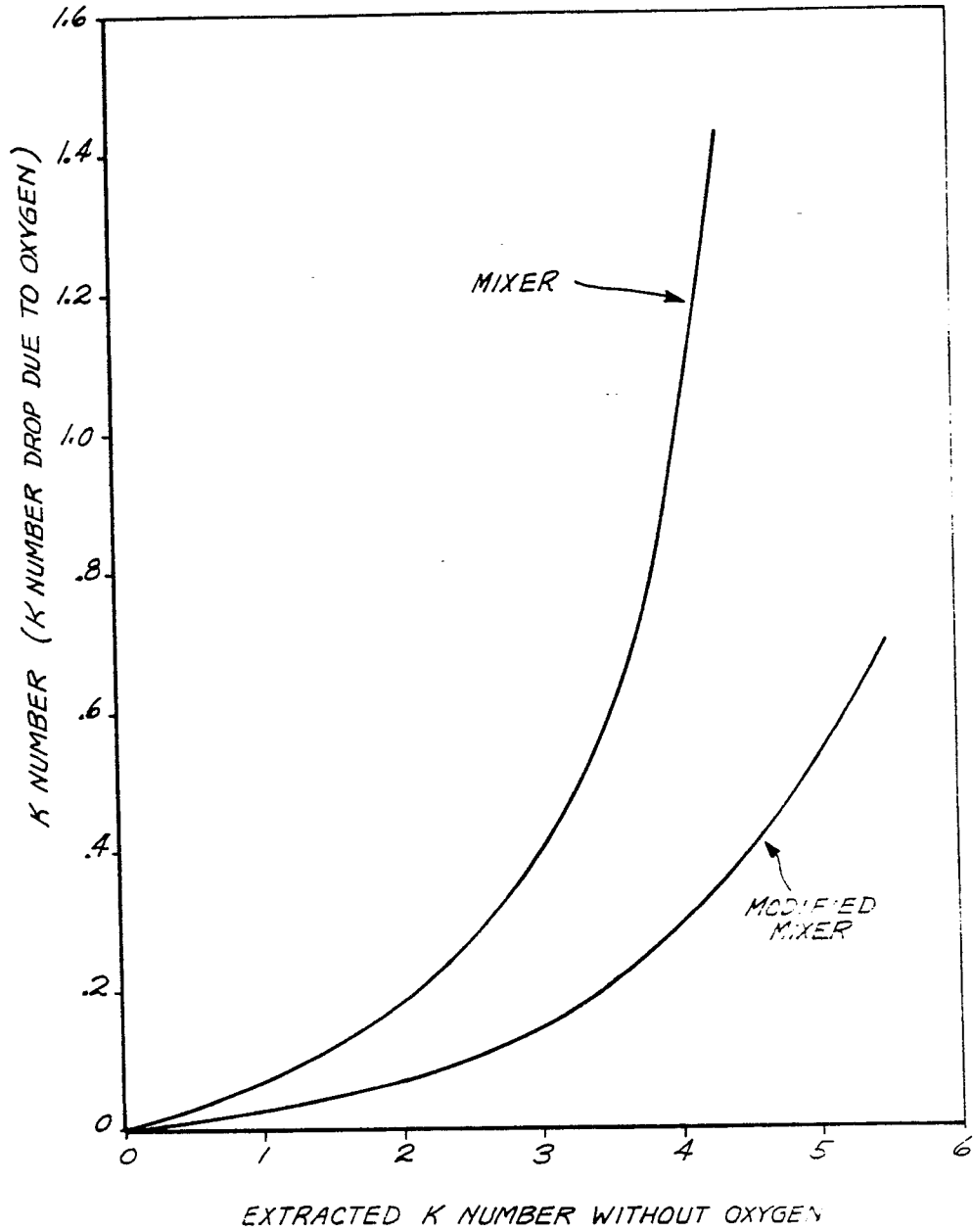


Fig. 25