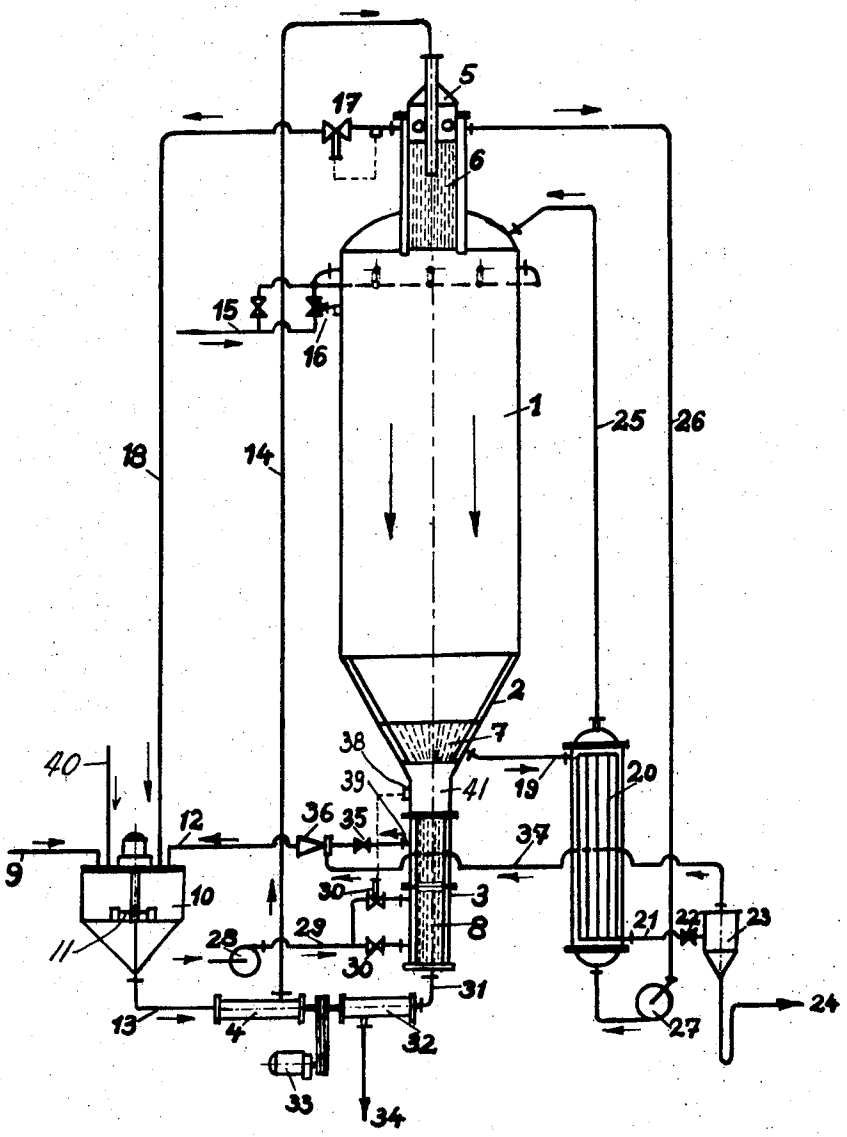
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PROCESS OF AND APPARATUS FOR THE CONTINUOUS MANUFACTURE OF CELLULOSE OR HEMICELLULOSE FROM CELLULOSIC FIBROUS MATERIALS

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PROCESS OF AND APPARATUS FOR THE CONTINUOUS MANUFACTURE OF CELLULOSE OR HEMICELLULOSE FROM CELLULOSIC FIBROUS MATERIALS

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The present invention relates to the manufacture of cellulose or hemicellulose, and more particularly to a continuous process of and an improved apparatus for the chemical digestion of cellulosic fibrous materials to obtain cellulose or hemicellulose.

Chemical digestion of cellulosic materials at temperatures exceeding 100° C. is known. This treatment is effected in upright, closed vessels under a pressure which prevents boiling of the treating liquid. It may include the chemical digestion treatment as well as the subsequent washing step in the same vessel. The fibrous material may be forced upwardly through the upright treating vessel by a worm conveyor while the treating liquid flows downwardly through the vessel in counter-current. Digesting liquid, for instance, sodium hydroxide solution, is added to the washing liquid approximately in the middle of the vessel so that digestion and washing are effected in the same vessel, one after the other. In this process, the treated fibrous material as well as the digesting liquid must be discharged from the vessel under the pressure under which treatment is effected.

This process requires not only a pressure-resistant vessel but the vessel must also be of considerable dimensions and must be provided throughout its length with a material-conveying means. This not only complicates the apparatus considerably and makes it accordingly very expensive but also subjects it to excessive wear and numerous breakdowns. For these and other reasons, the process has had no commercial success.

In another known continuous process for the manufacture of cellulose or hemicellulose from fibrous cellulosic materials, the cellulosic raw material is first treated under pressure with a digesting liquid flowing in the same direction as the material. The treated material is then removed from the treating vessel and washed in a second vessel counter-currently and under considerably reduced pressure. The pressure is so chosen that it just suffices to convey the treated material through the washing vessel. This process requires two separate apparatus and, therefore, is objectionable.

It is the principal object of the present invention to avoid the disadvantages of the first-named process while maintaining the structural advantage of combining the digesting and washing steps in a single vessel.

This and other objects are accomplished in accordance with this invention by conveying a fibrous cellulosic material, such as wood chips (pine, spruce, or other coniferous woods, or poplar and others), straw, esparto grass, cotton fibers, etc., vertically downwardly through an upright vessel. The digesting liquid, such as a solution of calcium disulfite containing free sulfur dioxide, sodium hydroxide solution, sodium hydroxide-sodium sulfate solution, and the like is flown concurrently to said cellulosic material through a digesting zone from the upper part of the vessel through the downwardly moving cellulosic material. The aqueous washing liquid is flown countercurrently from the lower part of the vessel through a washing zone. The spent digesting liquid continuously

coming from the digesting zone and the used washing liquid continuously coming from the washing zone are discharged in the same ratio in which they are supplied, in adjacent zones. Thereby a substantially stagnant mixture of spent digesting liquid and of used washing liquid is formed in said portion of the vessel. The digested cellulosic material passes through said stagnant mixture of spent digesting liquid and used washing liquid which mixture forms a separating layer between the high temperature of the digesting zone and the low temperature of the washing zone.

The present process advantageously combines digestion and washing in a single vessel and, in addition thereto, takes advantage of the concurrent digestion process wherein the material to be digested is conveyed by gravity. It has been found that, thereby, the washing zone in the vessel need only be comparatively small. A separate vessel for the washing process is not needed.

In accordance with a preferred feature of the present invention, the washing liquid discharged from the vessel may be used as conveying liquid for the cellulosic material by mixing it with the material and supplying the mixture under pressure to the upper part of the vessel. If the required digesting agent is added to said conveying washing liquid, said liquid will then also serve as digesting liquid. This has the advantage that that portion of the fibrous material which is discharged with the used washing liquid and which would otherwise be lost, is returned to the digesting process. It also considerably simplifies the serious problem of water disposal encountered in cellulose factories. Furthermore, the heat absorbed by the washing liquid from the digested material is recovered to a large extent.

The above and other objects, features, and advantages of the present invention will be explained more fully in the following detailed description of an embodiment of a plant constructed in accordance with the invention and schematically illustrated in the accompanying drawing.

The pressure-resistant vessel in which the cellulosic material is digested and washed, consists of an upper cylindrical portion **1**, which constitutes the digesting zone, a frusto-conical intermediate portion **2**, and the coaxially mounted tubular washing portion **3** of considerably reduced diameter. The intake piece **5** is coaxially mounted in closure **1***a* of the vessel. Sieves **6**, **7**, and **8** are mounted in said portions **5**, **2**, and **3**, respectively.

Mechanically comminuted fibrous cellulosic material is supplied through conduit **9** to mixer **10** in which there is mounted an agitator **11**. The conveying liquid supplied to the mixer through conduit **12** is mixed with the material in the mixer. The required chemical digesting agent or agents are added to the mixture through conduit **40**. The mixture is conveyed by conduit **13** to pump **4** and pumped through conduit **14** to intake **5** whence it enters the digesting zone. Pump **4** may be regulated to control the speed with which the material is conveyed through the pressure vessel.

A heated fluid, for instance, steam, is supplied to the vessel portion **1** through pipe **15** to obtain the desired digesting temperature. The quantity of fluid is controlled by valve **16** which is responsive to the digesting temperature in the vessel so that this temperature may be accurately controlled.

A constant digestion pressure in vessel **1**, **2**, **3** is assured by pressure-responsive valve **17** which opens conduit **18** when the pressure exceeds a given limit, thus permitting liquid to flow back into mixer **10**. This also maintains a constant liquid level in the vessel. Excess liquid passes through filter or sieve **6** and flows back through valve **17** and conduit **18** into the mixer.

Most of the spent digesting liquid is separated from the digested fibrous material through filter or sieve **7**

in the frusto-conical portion 2 of the vessel. Said spent liquid is discharged through pipe 19 and conveyed to heat exchanger 20 whence it travels through pipe 21 provided with throttle valve 22 to vessel 23 wherein the pressure is removed from the liquid. The liquid leaves the plant through discharge pipe 24.

In heat exchanger 20 the heat of the spent liquid is recovered and transferred to part of the digesting liquid which is continuously withdrawn from the digesting mixture through filter 6 and is constantly recirculated by means of circulating pump 27 through pipe 26, heat exchanger 20, and pipe 25. As a further result of such heat exchange and circulation of part of the digesting liquid thorough mixing of the fibrous material and the digesting liquid in digestion zone 1 is achieved.

The downwardly traveling material enters washing zone 3 after it has been treated in digesting zone 1 and after most of the spent digesting liquid has been filtered off through sieve 7. Fresh water is constantly pumped to washing zone 3 at different levels through branched pipe line 29 by pump 28. The washing liquid flows countercurrently through the digested fibrous material and is discharged at the upper part of filter or sieve 8. Simultaneously, a certain amount of wash water constantly leaves the vessel with the washed material through discharge conduit 31.

The amount of water entering the vessel is metered by valves 30 to correspond substantially to the quantity of water leaving the system whereby the liquid mixing zone 41 intermediate the digesting zones 1, 2 and the washing zone 3 is maintained substantially unchanged in the same portion of the vessel. In accordance with one feature of the invention, this control and maintaining of the intermediate mixing zone 41 is effected by making valves 30 responsive to the temperature in the mixing zone so that more water is supplied when the temperature rises and that the water supply is diminished when the temperature decreases. For this purpose, a thermostat 38 is mounted in the liquid mixing zone 41 to control operation of valve 30. When the mixing zone moves downwardly because of an excess supply of hot digesting liquid, thus raising the temperature in the mixing zone, increased water supply through pipe 29 will reverse this undesirable occurrence, and vice versa.

Mixing zone 41 lies intermediate the lower part of sieve 7 and the upper part of sieve 8 and has a temperature between that of the spent digesting liquid and the wash water. It forms a separation layer between the high temperature of digesting zone 1 and the temperature of washing zone 3 of the vessel.

The material-liquid mixture discharged from the vessel through conduit 31 is lead to hydraulic cylinder 32 which is mechanically coupled with pump 4. Preferably, cylinder 32 and pump 4 form a single hydraulic system. In accordance with this feature of the invention, the kinetic energy inherent in the downward flowing material-liquid mixture is at least partially recovered to operate the hydraulic system so that the motor 33, which drives the hydraulic system 4, 32, does not have to provide the entire work required to charge and discharge the material into and from the vessel. The treated material is conducted from cylinder 32 by conduit 34 to subsequent treating and/or collecting stations.

The wash water discharged from washing zone 3 is used as a conveying and treating liquid for the untreated fibrous material, being led from discharge opening 39 through pipe 12 into mixer 10. The liquid delivery is controlled by valve 35 to correspond to the desired capacity of the apparatus. Jet pump 36 is arranged in pipe 12 to suck the hot vapors from vessel 23 through pipe 37 into pipe 12 thereby preheating the wash water before it enters mixer 10.

The following examples serve to illustrate the mode of operation according to the present invention without, however, limiting the same thereto.

EXAMPLE 1

Charge

100 kg. of wheat or rye straw,
20 kg. of 50% sodium hydroxide solution, and
300 kg. of water of 80° C.

Energy requirements

50 kg. of steam of 640 cal./kg. and
0.08 kw. h. per kg. of digested pulp (absolutely dry).

Procedure

Chopped straw is continuously introduced into mixer 10 through screw conveyer 9. It is mixed therein with the required amount of 50% sodium hydroxide solution supplied through pipe 40 and is simultaneously diluted with hot used wash water supplied through pipe 12. The resulting mixture is pumped by means of pump 4 through pipes 13 and 14 into the upper intake part 5 of a boiler of 30 cu. m. capacity and holding about 6000 kg. of straw to be digested. The temperature of the mixture is about 80–90° C. The mixture contains between about 4% and about 5% of straw material to be digested. Jacket sieve or filter 6 provided in said intake part 5, is adjusted in such a manner that such a quantity of water is caused to return to mixer 10 through overflow valve 17 and pipe 18 that the residual straw-digesting liquid mixture entering cylindrical part 1 of the boiler contains about 25% of straw. The mixture to be digested is heated in the upper third of said part 1 to a temperature of 140° C. by directly supplying steam of about 10–12 atmospheres gauge and a temperature of 250–280° C. through pipe 15 at a place where uniform distribution of the heat throughout the entire boiler cross-section is assured. Thereby the moving liquid passing through said heating zone effects rapid distribution of the heat. The straw mixture is supplied to intake part 5 of the boiler at the same rate at which the digested material is continuously withdrawn from the bottom part of the boiler. Thus the column of straw to be digested and digesting liquid gradually and continuously moves downwardly within the boiler. The downward movement of the straw column proceeds with such a speed that the mixture of straw and digesting liquid remains in the boiler for about 4 to 5 hours. The pressure in the boiler is adjusted by suitably adjusting overflow valve 17. It is understood that the pressure in the boiler must be higher than the saturation pressure corresponding to a temperature of about 140° C. Usually a pressure of about 5 atmospheres gauge yields satisfactory results.

Sieve 7 adapted to remove spent digesting liquid, is provided in the frusto-conical part 2 of the boiler about 2 m. above the outlet for the digested pulp. Fresh wash water is introduced through pipe 29 and valves 30 into washing zone 3 of the boiler at the same rate at which spent digesting liquid is withdrawn from the digested mixture through pipe 19. The residual spent digesting liquid is completely displaced in the dense digested cellulose pulp within a zone of 50 cm. to 100 cm. of said washing zone 3. The temperature in said washing zone is about 25–30° C. As a result thereof the digested pulp leaves the boiler in a cold and washed state. The wash water consumption is very low. However, more wash water than actually required is consumed since a certain amount of the fresh wash water is used for diluting and withdrawing the digested pulp.

By adjusting the temperature in the intermediate zone 41 to and maintaining it at a temperature of about 110° C., constant operation of the continuous digestion process is assured.

The pressure of the spent digesting liquid is released in vessel 23 and the steam produced thereby is precipitated by water injection. The precipitated liquid is used to supplement the circulating liquid for conveying the mixture of straw and digesting agent from mixer 10 into the

boiler. The level of the liquid is kept constant by float adjustment of the injected water.

Conveyer pump 4 and discharge pump 32 are connected with each other by means of a continuously variable drive so that reversal of the rotation of the pumps is avoided.

For putting the boiler in operation, it is filled with cold water until excess water flows over through overflow valve 17. Conveyor pump 4 is then started without, however, introducing straw into mixer 10. Thereafter, sodium hydroxide solution is added to mixer 10 and is circulated through pipe 13, pump 4, pipe 14, boiler 1, overflow valve 17, pipe 18, and mixer 10. Simultaneously the sodium hydroxide solution is heated to about 100° C. in the upper part 5 of the boiler. Straw is then supplied to the mixer and cold water is withdrawn from the boiler through pipe 19. The rate of withdrawal of the cold water must correspond to the rate at which subsequently the spent digesting liquid is withdrawn. As a result thereof the column of straw and digesting liquid travels slowly downwardly. Heat is supplied in such a manner that the temperature of straw and digesting liquid in the cylindrical part 1 of the boiler is about 140° C. While filling the boiler with straw and digesting liquid, withdrawing pump 32 must, of course, not be in operation. As soon as the column of straw and digesting liquid has reached the frusto-conical portion 2 within about 4 hours to 5 hours, it is completely digested and can now be washed and withdrawn through conduit 31.

By carefully adjusting steam supply and withdrawal of spent digesting liquid continuous operation is effected under constant conditions.

EXAMPLE 2

Mechanically comminuted fibrous spruce wood of a fiber length of between about 5 mm. and about 20 mm. and a thickness between about 2 mm. and about 6 mm. are introduced through screw conveyer 9 into mixer 10. Mixer 10 is an iron vessel of 3 cu. m. lined with stainless steel and provided with agitator 11 of stainless steel. Used wash water heated by steam is simultaneously introduced through conduit 12 into mixer 10. The hot wash water and the fibrous spruce wood are intimately mixed with each other. At the same time neutral sodium sulfite solution containing about 3% Na_2SO_3 is admixed thereto in such a manner, that the mixture contains about 150 g. Na_2SO_3 per 1 kg. wood. The resulting intimate mixture of sodium sulfite solution and fibrous wood particles is then conducted through pipe 13 and is pumped by means of pump 4 through pipe 14 into the upper part of vessel 1.

Vessel 1 is a pressure-resistant, iron vessel lined with stainless steel. The cylindrical part of said vessel has a capacity of about 30 cu. m. Its height is about 1000 cm. and its diameter about 190 cm. The speed with which the mixture of wood and digesting liquid is conveyed by pump 4 and pipe 14 into and through vessel 1 is between about 60 cu. m. and about 80 cu. m. per hour, depending upon the type of wood to be digested. The most suitable speed is readily determined by preliminary tests.

The mixture of wood and digesting liquid first enters the intake piece 5 which is an iron tube lined with acid-resistant material and is provided with sieve 6 consisting of perforated sheet metal, the holes of which have a diameter of about 4 mm.

Heating of the digestion mixture during digestion in vessel 1 is effected by introducing superheated steam of a temperature of 260° C. through pipe 15. Control valve 16 regulates admission of said superheated steam so that the temperature in digesting vessel 1 is between about 140° C. and about 150° C. The pressure in digesting vessel 1 is kept between about 4 atm. and about 6 atm. As soon as a pressure of 6 atm. is exceeded, part of the digesting liquid separated by sieve 6 from the wood particles is caused to flow back into mixer 10 by means of pressure responsive valve 17 and through pipe 18. The time required for passage of the digestion mixture through the cylindrical part of vessel 1 is between about 3 hours and about 6 hours. The mixture then passes through sieve 7 in frusto-conical part 2 of vessel 1 where most of the spent digesting liquid is separated from the digested wood particles.

The digested wood particles, separated from the greater part of the spent digesting liquid in filter 7 enter the cylindrical washing zone 3 having a height of about 400 cm. and a diameter of about 90 cm. Cold water is introduced into said washing zone through branched pipe line 29 and flows in upward direction through the descending digested wood particles. Part of said wash water leaves the washing zone at its bottom together with the washed digested wood particles through conduit 31 while the remainder of the wash water leaves the washing zone at its top through discharge opening 39. The amount of wash water used per 1 kg. of fibrous wood particles charged into vessel 1 is between about 15 l. and about 20 l. The temperature of the used wash water leaving the washing zone through discharge opening 39 is about 75° C. Sieve 8 serves to separate the used wash water from the washed digested wood particles leaving the washing zone through discharge conduit 31.

Due to the provision of discharge pipe 19 through which most of the spent digesting liquid is removed from the digested wood particles at the bottom of the digesting zone and of discharge opening 39 through which most of the used wash water is removed from the washed cellulose substantially at the top of the washing zone an intermediate zone 41 is formed wherein digesting liquid and washing liquid are mixed and remain stagnant therein. The temperature of said mixing zone 41 at the place where thermostat 38 is provided, is about 110° C. Since this thermostat 38 is connected with valves 30 which regulate the supply of wash water, it is readily possible to maintain said temperature in mixing zone 41 by increasing or decreasing the wash water supply.

The resulting cellulose fibers are further processed, if desired, bleached, dried, and converted into sheet form or the like. About 70 kg. of air-dried cellulose are obtained from 100 kg. of fibrous wood.

It is, of course, also possible to adjust the continuous process according to the present invention to a lower digestion temperature, for instance, to a temperature between about 115° C. and about 130° C., and to operate at a lower pressure, for instance, at a pressure between about 2.5 atm. and about 5.0 atm. Digestion then proceeds more slowly. The quality of the resulting cellulose is, however, improved.

In place of calcium disulfite solutions there can be used other digesting solutions as they are mentioned hereinabove.

While the present invention has been described in connection with one specific digesting system, it will be obvious that many variations and modifications may occur to those skilled in the art, particularly after they have benefited from the present teaching, without departing from the spirit and scope of the invention as defined in the appended claims.

The following example is given to further illustrate the present invention.

EXAMPLE 3

Charge

100 parts by weight of rye straw,
10 parts by weight of sodium hydroxide in the form of a 50% sodium hydroxide solution, 300 parts by weight of water of a temperature of 80° C.,
50 parts by weight of steam of 640 cal./kg.

The procedure is the same as described hereinabove in Example 1.

Digestion temperature: 140° C.

Concentration of the sodium hydroxide solution during digestion: about 15% NaOH. This concentration is maintained by continuous addition of sodium hydroxide.

Heat consumption: 14.8 kg. of steam for 100 kg. of straw/kg. or for 70 kg. of cellulose pulp corresponding to 0.46 kg. of steam per kg. of pulp.

Loss of heat on digesting 100 kg. of straw:

	Cal.
65 l. of spent digesting liquid of a temperature of 75° C.	3,500
5 l. loss due to evaporation	2,700
Heat dissipated by radiation	1,300
	7,500

Electrical energy required for mixing and feeding the digesting mixture into the boiler: 0.08 kw. h./kg. of cellulose.

Duration of digestion: 4 hours.

Each 100 parts by weight of straw and sodium hydroxide solution require 1.5 cu. m. of boiler space.

Apparatus for producing 8 metric tons of cellulose per day:

Boiler capacity—cu. m.	16
Highest pressure—atm. gauge	6
Required pressure—atm. gauge	5
Highest digestion temperature—° C.	150
Lowest digestion temperature—° C.	135

Of the boiler space:

20% are required for heating the digestion mixture supplied from the mixer to a temperature of 140° C.
60% are required for digestion, and
20% for washing.

The contents of cellulosic material in the digestion mixture and of cellulose pulp in the washed material in the various zones are as follows:

3% in mixer 10, for supplying to the boiler, and in intake part 5;
20% in upper part 1 of the boiler;
25% to 28% after withdrawing part of the spent digesting liquid;
4% to 5% after washing and during discharging of the cellulose from the boiler.

It may be mentioned that in the intake part and the upper part of the boiler the straw is lighter than the sodium hydroxide solution. At the place where steam is introduced into the boiler for heating the digestion mixture to a digestion temperature of 140° C., the mixture is converted into a semi-fluid mixture while in that part of the boiler where digestion takes place, the resulting cellulose pulp is heavier than the digesting liquid.

I claim:

1. In a continuous process of chemically digesting fibrous cellulosic material to yield cellulose and hemicellulose, said digestion process being carried out at a temperature exceeding 100° C. and under pressure in a closed vertical chamber wherein digestion as well as subsequent washing of the digested cellulosic material are effected, the steps which comprise reacting an intimate mixture of fibrous cellulosic material concurrently with the digesting liquid in the upper part of said chamber, washing the digested cellulosic material countercurrently in the lower part of said chamber, and withdrawing the spent digesting liquid obtained in the upper part of the chamber from the continuously supplied digesting liquid, and the wash water continuously supplied to the lower part of said chamber, in adjacent zones in a portion of the chamber between the digesting zone and the washing zone in the same ratio in which they are supplied, thereby forming a substantially stagnant mixture of spent digesting liquid and used wash water in the intermediate zone between the discharge outlets of spent digesting liquid and used wash water, said stagnant mixture of spent digesting liquid and used wash water forming a separating layer between the temperature of the digestion zone and the temperature of the washing zone, the digested cellulosic material traveling through said intermediate zone from the digestion zone to the washing zone.

2. The process according to claim 1, wherein the used wash water discharged from the washing zone serves as conveying liquid to convey and supply the cellulosic material to the digestion zone, and, after addition of the digesting agent, as digesting liquid.

3. The process according to claim 1, wherein the wash water supply to the chamber is controlled and adjusted responsive to the temperature in the intermediate zone in such a manner that it is increased when the temperature in said intermediate zone rises, and is diminished when said temperature decreases.

4. An apparatus for treating fibrous material by means of a liquid, comprising an upright pressure-resistant vessel constituted by an upper portion, a downwardly tapered intermediate portion and a lower portion, an upper closure for said vessel, an intake mounted in said closure, conduit means for supplying said material and a treating liquid to said intake, means for maintaining an elevated temperature in said upper portion, a filter mounted coaxially in said intermediate portion, discharge conduit means connected to said intermediate portion for discharging spent treating liquid filtered through said filter from the vessel, conduit means connected to said lower portion, pressure means for supplying a washing liquid through the last-named conduit means for upward flow in said lower portion, a longitudinally extending filter coaxially mounted in the lower portion, discharge conduit means connected to the lower portion above the last-named conduit means for discharging used washing liquid filtered through the longitudinal filter, the two filters being axially spaced from each other to form a zone between the intermediate portion and the lower portion of the vessel, a lower closure for the vessel, and a discharge conduit connected to the lower closure.

5. The apparatus of claim 4, also comprising a longitudinally extending filter coaxially mounted in the intake, and discharge conduit means connected to the intake for discharging treating liquid filtered through the latter filter from the intake.

6. The apparatus of claim 4, comprising pumping means arranged in the first-named conduit means for supplying the material and treating liquid to the vessel under pressure, hydraulic means arranged in the last-named discharge conduit and responsive to pressure of material discharged therethrough, and means for mechanically coupling the pumping means and the hydraulic means.

7. The apparatus of claim 6, comprising a common drive means for the pumping means and the hydraulic means.

8. The apparatus of claim 4, comprising a mixer for mixing the fibrous material and the treating liquid together, said mixer having a discharge means connected to the first-named conduit means, and conduit means connected to the discharge conduit means of the lower portion of the vessel discharging into the mixer whereby used washing liquid discharged from the vessel is supplied to the mixer.

9. The apparatus of claim 4, wherein the means for maintaining an elevated temperature in the upper portion of the vessel comprises conduit means for supplying steam to the upper portion and means responsive to said temperature for controlling the steam supply.

10. The apparatus of claim 4, comprising a heat exchanger, the conduit means connected to said intermediate portion of the vessel discharging the spent treating liquid into said heat exchanger, liquid discharge means connected to said heat exchanger, and liquid circulating

means connected between the heat exchanger and the intake of the vessel.

11. The apparatus of claim 4, comprising a container connected to said treating liquid discharge means, the treating liquid being relieved of pressure in said container, conduit means connected between said container and the discharge conduit means which are connected to the lower portion of the vessel, whereby hot fluid is conducted from the container to the discharge conduit means, and means for conducting the discharged used washing liquid and the hot fluid to the means for supplying the fibrous material to the vessel.

12. The apparatus of claim 4, comprising valve means in the conduit means connected to the lower portion of the vessel for controlling the supply of the washing liquid thereto, and thermostatic means arranged in the zone between the intermediate and lower vessel portions, the valve means being responsive to the thermostatic means.

13. An apparatus for digesting a cellulosic fibrous material consecutively with an active digesting liquid and with a washing liquid, comprising an upright pressure-resistant vessel constituted by a substantially cylindrical upper portion, a downwardly tapering frusto-conical intermediate portion, and a tubular lower portion of substantially smaller diameter than the cylindrical portion and coaxial therewith, an upper closure for said vessel, a tubular intake mounted in said closure, a mixer for mixing the fibrous material and the digesting liquid, conduit means connected between the mixer and the intake, pumping means arranged in said conduit means for supplying the material and the digesting liquid under pressure, a longitudinally extending tubular filter in said intake for filtering digesting liquid from the fibrous material-liquid mixture, discharge conduit means connected to the intake to discharge the filtered digesting liquid therefrom, steam supply means connected to the upper portion of the vessel, a frusto-conical filter mounted coaxially in said frusto-conical portion of the vessel, discharge conduit means connected to the latter portion for discharging spent digesting liquid filtered through the latter filter from the vessel, conduit means connected to the lower tubular portion of the vessel, pumping means for supplying a washing liquid through the last-named conduit means for upward flow in said tubular portion, a longitudinally extending tubular filter mounted coaxially in the tubular portion, discharge conduit means connected to the tubular portion above the last-named conduit means for discharging washing liquid filtered through the last-named filter, the filters in the intermediate and the lower portions of the vessel being axially spaced to form a zone between said portions, thermostatic means arranged in said zone, valve means arranged in the conduit means supplying the washing liquid to the lower portion of the vessel, said valve means being responsive to the thermostatic means, a lower closure for the vessel, and a discharge conduit connected to the lower closure.

14. The apparatus of claim 13, comprising pumping means aranged in the conduit means connected between the mixer and the intake, and a hydraulic cylinder having an input and an output, the output being connected to the last-named discharge conduit and the input being mechanically coupled to the pumping means.

15. The apparatus of claim 14, comprising a common drive motor for the pumping means and the hydraulic cylinder.

16. The apparatus of claim 13, wherein said discharge conduit means connected to the lower portion of the vessel discharges into the mixer whereby used washing liquid discharged from the vessel is applied to the mixer.

17. The apparatus of claim 16, comprising a heat exchanger, the conduit means connected to said intermediate portion of the vessel discharging the treating liquid into the heat exchanger, a liquid container, conduit means connecting the heat exchanger to the liquid container, the spent digesting liquid supplied through said conduit means being relieved of pressure in said container, liquid discharge means connected to said heat exchanger, liquid circulating means connected between the heat exchanger and the intake of the vessel, additional conduit means connected between said container and the discharge conduit means which are connected to the lower portion of the vessel, and means for forcing hot fluid from said container into the last-named discharge conduit means.

18. The apparatus of claim 13, comprising valve means in the conduit means connected to the lower portion of the vessel for controlling the supply of washing liquid thereto, and thermostatic means arranged in the zone between the intermediate and lower vessel portions, the valve means being responsive to the thermostatic means in such a manner that more washing liquid is supplied upon a rise in the temperature in said zone and less washing liquid is supplied upon a decrease in said temperature.

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