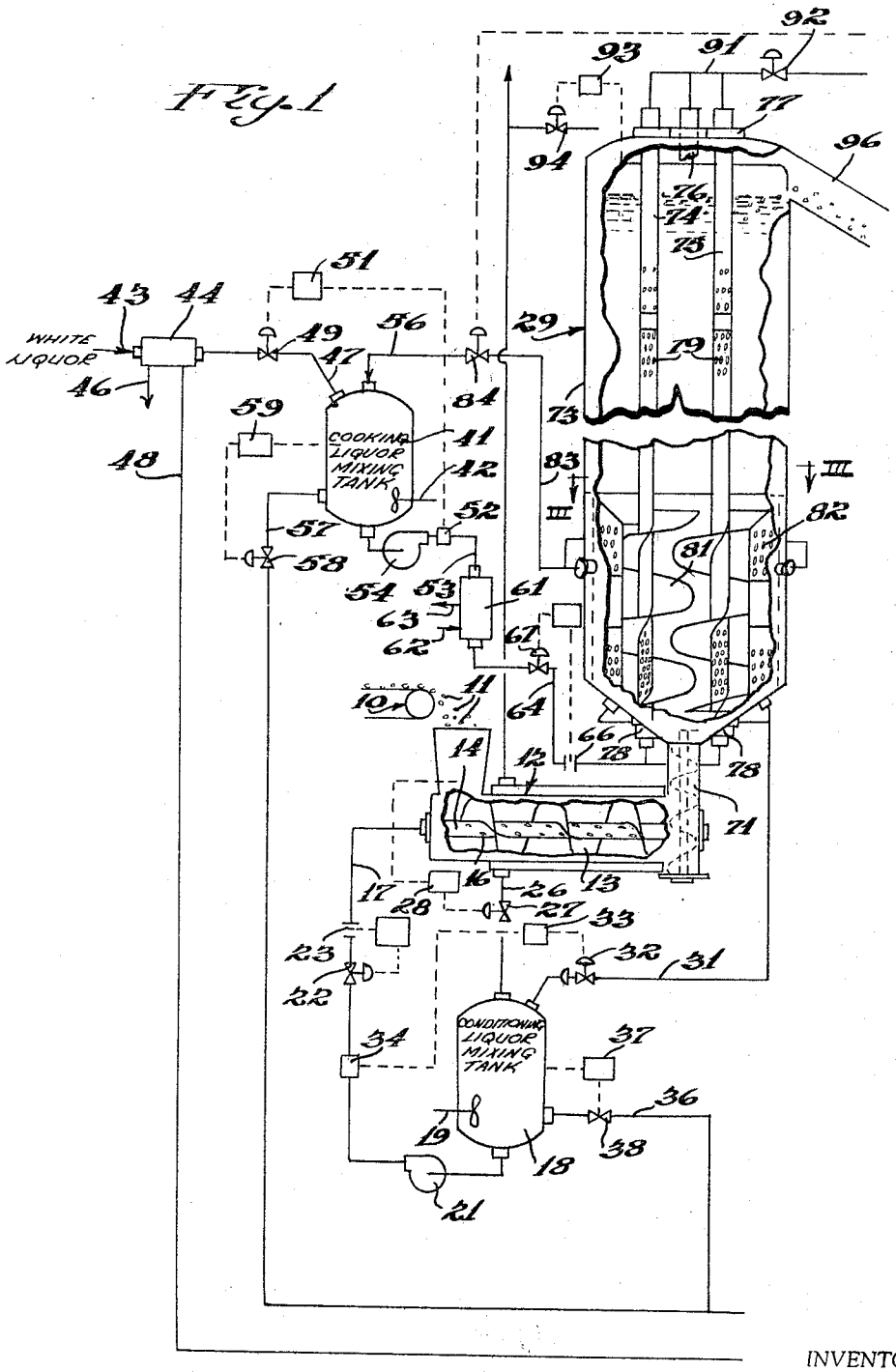
March 28, 1967 E. J. JUSTUS ETAL 3,311,530

CONTINUOUS DIGESTOR

Filed June 28, 1963 2 Sheets-Sheet 1

Fig. 1



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CONTINUOUS DIGESTOR

Filed June 28, 1963 2 Sheets-Sheet 2

Fig. 2

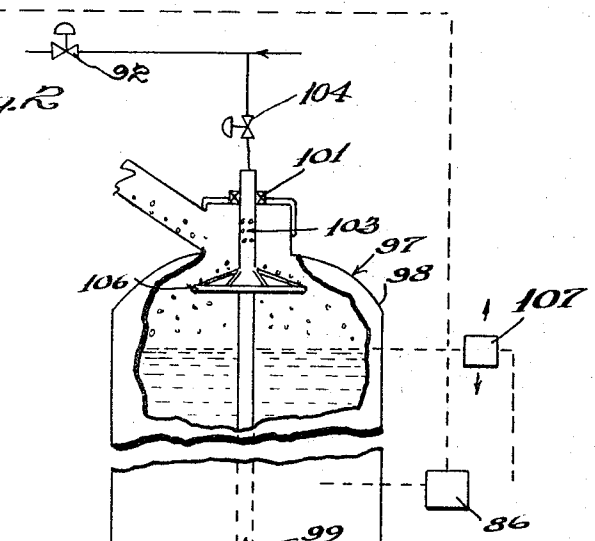
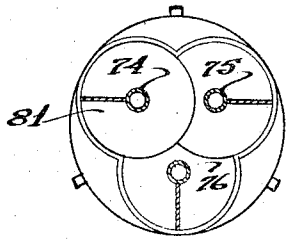


Fig. 3



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United States Patent Office 3,311,530
Patented Mar. 28, 1967

3,311,530

CONTINUOUS DIGESTOR

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Filed June 28, 1963, Ser. No. 291,523
10 Claims. (Cl. 162—19)

The present invention relates to an improved continuous chemical pulping process, and to apparatus which is employed in that process.

In a typical chemical pulping process such as the kraft process, active pulping ingredients such as sodium hydroxide and sodium sulfide are used to treat the wood material usually consisting of wood chips. The dissolved organic constituents in the spent pulping liquors are burned for steam generation, and the inorganic pulping chemicals are recovered and reused. While the mechanics of such chemical pulping processes are reasonably well understood, heretofore it has been difficult to provide a suitable continuous process for pulping because of the extremes in process conditions which have to be observed for proper treatment of the wood.

The present invention provides such a continuous process, and apparatus for use in the practice of the process. The continuous pulping process of the present invention is designed to produce uniformly high grade pulps by providing positive flow of chips and liquors, through carefully controlled process conditions.

An object of the present invention is to provide an improved continuous chemical pulping process for producing cellulosic fibers useful in the manufacture of paper.

Still another object of the invention is to provide an improved apparatus for carrying out a continuous chemical pulping process.

A further object of the invention is to provide a continuous pulping system with a novel preconditioning step for treating the wood chips.

Still another object of the invention is to provide an improved saturator in which the alkali content of the wood is raised to the desired level under carefully controlled process conditions.

Another object of the invention is to provide a continuous hot stock pressure washing system for pulp leaving a continuous digestor.

Still another object of the invention is to provide a pulping system which is applicable to all types of wood chips.

Another object of the invention is to provide a continuous chemical pulping method which includes positive control over the movement of wood chips in the critical stages of liquor penetration and diffusion.

Other objects of the invention include the provision of a chemical pulping process which is completely flexible in the matter of regulating process conditions in each stage, variations in production rate without changing the temperature, pressure, or liquor concentration in the digestor, faster start-ups and shutdowns, and lower power requirements.

In the first stage of the new process, wood chips of any type are first submerged for a few minutes (3 to 5 minutes or so) in a relatively weak alkaline black liquor at atmospheric pressures and temperatures on the order of 200° F. Typical reaction conditions in this stage include a temperature of about 205° F., and an alkalinity of about 10 grams of effective alkali per liter of solution. The pretreatment of the wood chips with the liquor serves to remove air and some of the noncondensable gases from the chips, it increases the moisture content of the chips thereby improving the susceptibility of the chips

to ionic diffusion in the subsequent stages of the process and it serves to preheat the chips.

Following the preconditioning step, the black liquor is drained from the chips and replaced with a white cooking liquor in a saturation zone. In this zone, the temperature of the cooking liquor is gradually increased from about 220° F. to about 290° F. for a period of about 30 to 40 minutes. During this gradual increase in temperature, the pressure on the liquid surrounding the chips is decreased from about 140 to about 120 p.s.i. gauge. The use of higher pressure at the early stages accelerates the mass penetration of liquor into the open structure of the wood. The extended periods of time are not necessary specifically to secure penetration of the wood but are important in securing proper diffusion of the pulping ions into the fine fiber structure. It is important to avoid too rapid a temperature increase in the diffusion stage as this might result in deleterious localized chemical attack before the diffusion process had time to distribute the treating liquor uniformly throughout all the fiber walls.

Even if a moderate temperature is employed in the diffusion step, excessive dissolution of the carbohydrate material can take place if the treating liquor has too high an alkaline concentration. We have found it desirable, therefore, to gradually increase the alkali concentration during the saturating stage from a relatively low value of 15 to 30 grams per liter of effective alkali during the first 15 minutes or so and then allow the alkali concentration to decrease slowly during the remainder of the saturating period until the desired amount of the pulping chemical is absorbed by the chips. For most types of pulp, the treatment should be carried out until the mass being treated absorbs 14 to 18% by weight of active alkali. During the saturation period, the liquor is slowly circulated past the chips and the instantaneous ratio of liquid to wood is gradually decreased from about 10 to 1 to 5 to 1 by weight. When using a typical kraft cooking liquor, the sulfidity of the cooking liquor should be at least about 25%.

At the completion of this saturation period, the liquid to wood ratio is adjusted to about 4 to 1 and the temperature is increased rapidly with direct steam injected directly into the saturating zone. Typically, the pressure at this stage is the same as that of saturated steam at the maximum cooking temperature being used which may be about 120 p.s.i. gauge at 350° F.

Next, the alkali and steam treated chips are passed, in an environment of steam, to a separate cooking or digesting zone.

During digestion, the ratio of liquid to fibers is kept at about 4 to 1, and the treatment time is typically from 50 to 60 minutes at a temperature of about 350° F. As the reaction proceeds, the effective alkali concentration declines gradually until a final concentration of 10 to 12 grams per liter or so is reached. At the completion of the digestion reaction, the cooking is terminated by dilution with a liquor of lower temperature and lower concentration than the cooking liquor. The final pressure in the cooking stage may be on the order of about 140 p.s.i. gauge.

The present invention employs an improved continuous hot stock pressure washing system for the material leaving the digestor. It consists of a number of washing stages in series employing successively decreasing temperatures and pressures. In the first washing stage, a filtrate recovered from a succeeding washing stage is added to the pulp and liquor mixture entering the first washing stage until the liquor to fiber ratio reaches about 15 to 1 and the temperature is reduced to about 290° F. As the fiber is filtered off in the first washing stage, the pressure is lowered to about 45 p.s.i. gauge. The filtrate from the

first washing step is partly recycled to the cooking liquor and preconditioning liquor mixing tanks, while the remainder goes to a recovery system.

The first washing stage is usually effective to produce a consistency of about 25%. In a succeeding washing stage, this stock is diluted with white water and filtered again, the filtrate being used to dilute the incoming stock to the first washing stage, as previously mentioned. During this subsequent step, the pressure is gradually reduced to atmospheric pressure and a high density pulp is recovered.

A further description of the present invention will be made in conjunction with the accompanying drawings which illustrate a continuous kraft pulping and washing system embodying the principles of the present invention.

FIGURE 1 is a view, partly schematic, illustrating a portion of the apparatus of the present invention;

FIGURE 2 is a continuation of FIGURE 1, illustrating the remainder of the apparatus; and

FIGURE 3 is a cross-sectional view taken substantially along line III—III of FIGURE 1.

As shown in the drawings:

In FIGURE 1, reference numeral **10** indicates generally a belt conveyor for transferring wood chips **11** to a chip conditioner generally illustrated at reference numeral **12** of the drawings. The conditioner **12** includes a screw feed conveyor **13** secured to a hollow shaft **14** about whose periphery there is a series of spaced apertures **16**. A relatively weak alkaline black liquor is introduced through the hollow shaft **14** from a line **17** so that the liquor emerges from the apertures **16** and serves to precondition the chips in order to reduce the noncondensable gas content, to increase the moisture content of the chips, and to preheat the chips. The conditioning liquor is derived from a conditioning liquor mixing tank **18** in which an agitator **19** is provided. A pump **21** circulates the liquor from the tank **18** into the line **17**. A valve **22** is located in the line **17** to control the flow rate, and a flow rate controller **23** is provided to sense variations in the flow rate and thereby adjust the valve to compensate for such variations.

Some of the liquor drained from the chips in the conditioner **12** is recirculated from the conditioner **12** to the tank **18** through a line **26** controlled by a valve **27**. A liquid level controller generally indicated at numeral **28** and having a sensing means (not shown) in the chip conditioner **12** controls the operation of the valve **27** in response to the liquid level appearing in the conditioner.

Additional amounts of black liquor are received from a saturator **29** through a line **31** controlled by a valve **32**. A liquor concentration controller **33** having a sensor **34** located in the feed line **17** controls the operation of the valve **32** in response to changes in concentration of the black liquor being circulated to thereby compensate for any variations which might occur.

The mixing tank **18** also receives black liquor from a recovery system associated with the washing zones through a line **36**. A liquid level controller **37** responsive to the level of liquid in the tank **18** controls a valve **38** in the line **36** and thereby adjusts the amount of black liquor being recycled in this line.

Mixing of the cooking liquor takes place in a tank **41** supplied with an agitator **42**. White liquor is introduced through an inlet line **43** and passes through a heater **44** from which condensed steam used to heat the mass is withdrawn by a condensate line **46**. The heated liquor is then passed by means of a line **47** into the tank **41**. At the same time, a certain amount of recycle liquor enters the heater **44** through a line **48** from the recovery system subsequently to be described. The amount of material entering through the tank **41** through the line **47** is controlled by a valve **49** which, in turn, is controlled by a liquor concentration controller **51** actuated by a sensor **52** located in the output line **53** of the mixing tank **41**. The output line **52** is fed by means of a pump **54**. Additional amounts of cooking liquor are derived from the saturator **29** through a line **56**.

Some amount of black liquor is also introduced into the tank **41** through a line **57** controlled by a valve **58** which, in turn, is controlled by a liquid level controller **59** responsive to the level of liquid in the tank **41**.

The pump **54** delivers the cooking liquor through a heater **61** to which steam is introduced by means of a steam line **62** and condensate is withdrawn by means of a line **63**. The heated cooking liquor is passed by means of a line **64** to the inlet of the saturator **29**, and a flow rate controller **66** in that line controls the operation of a valve **67** to adjust the flow rate.

The preconditioned wood chips leaving the conditioner **12** are lifted into the inlet end of the saturator **29** by means of twin screw pump **71**. In the saturator **29**, the chips are subjected to treatment at progressively increasing temperatures and progressively decreasing pressures until the requisite amount of alkali has been taken up (usually 14 to 18% by weight). The saturator **29** itself has certain novel structural features which make it possible for the process variables within the saturator to be carefully controlled. The saturator **29** includes a vessel or chamber **73** in which three hollow shafts **74**, **75** and **76** are mounted for rotation by means of bearings **77** and **78**. As indicated in FIGURE 1, each of the shafts **74** to **76** inclusive contains apertures **79** extending for a major portion of the length of the shaft. Secured in spaced relation along the shaft **74** to **76** are a series of helical screw flights **81**, the flights **81** from the respective shafts being in interdigitated relationship with respect to each other. The spacing between the individual flights **81** on adjoining shafts is such that the flights are able to propel the wood chips being treated upwardly but not being so close that they exert any substantial compression on the material being propelled. The cooking liquor entering through the line **64** is introduced into one end of each of the shafts **74** to **76** and as it passes through the apertures **79** it comes into contact with the upwardly moving chips enabling the diffusion of the cooking liquor to take place uniformly throughout the fiber walls. The liquor is then withdrawn through a strainer **82** whereupon at least a portion of the liquor is returned to the cooking liquor mixing tank **41** through a line **83** controlled by a valve **84**. The valve **84**, in turn, is controlled by a liquid level controller **86** which is sensitive to the level of liquid in the digestor to be described subsequently.

Liquor settling to the base of the chamber **29** is withdrawn through the line **31** and passes to the conditioning liquor mixing tank **18**.

The circulation pattern provided in the saturator **29** provides for the gradual rise and fall in liquor concentration as the chips move upward. Then, the temperature of the chips is raised substantially by introducing steam into the other ends of the hollow shafts **74** to **76** from a steam line **91** under the control of a valve **92**. Pressure control in the upper portion of the saturator vessel **29** is maintained by a pressure controller **93** which operates a valve **94** to vent gases from the chamber as the pressure becomes excessive.

By the time the chips reach the top of the vessel and steam is being introduced, they have been saturated with the proper amount of cooking liquor. The steam then functions to raise the temperature of the treated chips to the maximum cooking temperature whereupon the chips are transferred in a steam environment to a chute **96** connecting the saturator **29** with a digestor **97**. The latter includes a casing **98** in which a hollow shaft **99** is mounted for rotation between a pair of opposed bearings **101** and **102**. Of course, if desired, the shaft **99** may also be supported in cantilever fashion if a particular installation makes that type of support desirable. The hollow shaft **99** has apertures **103** through which the steam enters the chamber, the steam being under the control of inlet valve **104**.

Also supported on the shaft 103 is a baffle type distributor 106 which distributes them more uniformly within the chamber. The liquid level in the digestor 97 is kept at a point near the chip level by controlling the rate of liquor withdrawal from the saturation vessel 29. Pulp production is varied by adjusting the level of chips in the digestor 97, through the medium of a chip level controller 107 which is coupled to the variable speed drives on the washer assemblies to be subsequently described.

Diluting and cooling wash liquor is introduced through inlets 111 and 112 fed from a line 113 and into the bottom of the digestive vessel from a line 114. The base of the shaft 99 is also provided with an agitator or impeller 116 which serves to break up the pulp and transfer it to one of a series of washers 117 and 118 operating in series. The washers 117 and 118 may comprise twin screw decompression pumps each being provided with a drainer 119 and 121. White water is introduced into each of the washers 117 and 118 through their respective inlets 122 and 123. The rate of feed from the digestor 97 to the first washer 117 is controlled by the chip level controller 107 which operates on the variable speed drive energizing the screws in the washer.

Digestor pressure is gradually released as the stock passes through the washers. The steam flashing off the liquor due to the lower pressure on the back side of the drainer causes the liquor to drain from the fiber and no squeezing action on the pulp is required. Liquor withdrawn from the drainer 119 passes by means of a line 126 into a flash tank 127, while liquor was drawn from the drainer 121 passes by means of a line 131 into a flash tank 132. The temperature of the liquid leaving the flash tank 132 and being pumped by a pump 133 into the line 113 is controlled by a temperature controller 134 which is sensitive to the temperature inside of the vessel 97, and controls a valve 136 to provide greater or lesser amounts of the wash liquid in the line 113. The liquid leaving the flash tank 127 is divided into separate portions, one portion going to the lines 36 and 57 feeding the mixing tanks 18 and 41, while another portion is passed through a line 137 to a set of evaporators. A valve 138 in the line 137 is under the control of a liquid level controller 139 sensitive to level changes in the flash tank 127. The overhead flash tank 127 is used for heating purposes and is directed into the line 48 which preheats the white liquor in the heater 44. A valve 141 controlled by a pressure controller 142 responsive to pressures in the flash tank 127 controls the amount of heating fluid thus being circulated.

The system of the present invention involves several advantages over other continuous pulping systems. For example, there is no liquor removal from the cooking vessel after the chips begin to soften. The heating of the chips to the cooking temperature is done with direct steam, thereby eliminating strainers, pumps, and heat exchangers in the cooking vessel.

In the saturator, positive control over chip movement enables better diffusion and prevents channeling. Circulation of liquor in this stage is improved by a multipoint injection of the liquor into the saturator.

The feature of recirculating black liquor provides for conditioning the chips for subsequent saturation and for recovery of some of the sensible heat contained in the chips.

Since the saturation and the digestion take place in separate vessels, it is possible to achieve more flexible regulation of the process conditions in each stage. It is also possible to vary the production rate without changing the temperature, pressure or liquor concentration in the digestor. The isolation of the two stages into separate vessels also provides for faster start-ups and shutdowns, lower structures and lower power requirements for lifting the chips and the liquor.

The upwardly directed flow in the saturator provides an extra hydrostatic head in the initial penetration stage, and provides natural convection currents in the gradual

temperature rise period. The saturator also takes advantage of the buoyancy of the chips entering the bottom of the vessel thereby reducing the amount of uplift power required.

The use of a down flow system in the digestor permits using a simple gravity system to convey the chips, and to move the liquor of increasing density concurrently with the chips. It also enables a lower temperature liquor injection at the bottom to terminate the cooking.

The preconditioning of the chips can also take place directly in the saturator vessel. For example, a kraft liquor at a moderate concentration of about 30 to 35 grams per liter of effective alkali can be introduced into the upper part of the saturator at a temperature near boiling. This liquor then flows down in a path countercurrent to the chips, thereby decreasing in temperature and concentration so that at the bottom of the vessel it will provide the mild alkaline treatment to the entering charge. In this way, the liquor to first come in contact with the chips has an effective alkali concentration of 15 to 20 grams per liter and a temperature of about 120 to 150° F. The pressure of steam on the top of the saturator vessel plus the hydrostatic head provides sufficient force to drive the weak liquor into the chips.

While the foregoing discussion has been based primarily upon the use of the process and apparatus in the kraft pulping process, the same equipment can be used to produce sulfite type pulps continuously. Following an alkali treatment at the lower part of the saturator, sulfur dioxide gas can be injected above the liquid level in the saturator in order to produce sodium sulfite or bisulfite inside the chips so that thereafter, a sulfite cook could be carried out.

It should also be evident that various other modifications can be made to the described embodiments without departing from the scope of the present invention.

We claim as our invention:

1. A continuous chemical pulping process which comprises treating wood chips in a relatively weak alkaline black liquor, draining said black liquor from the treated chips, saturating the treated chips in white liquor while gradually increasing the temperature of said white liquor, subjecting the treated chips to direct contact with steam to raise the chips to a cooking temperature, cooking the thus treated material under conditions of elevated temperature and pressure, diluting and cooling the pulp stock thus produced in a first washing stage with a filtered cooling liquor derived from a succeeding washing stage, diluting the pulp stock after the first washing stage with white water in said succeeding washing stage, filtering said pulp stock, and passing the filtrate thus recovered to said first washing stage to dilute said pulp stock entering said first washing stage, the chips moving essentially downstream through such saturating and subsequent steam contacting steps exposed to apertured conduit means, such process also including the steps of feeding such saturating liquor to the chips through the upstream end of such conduit means and feeding the steam to the chips through the downstream end of such conduit means and generally countercurrent to such downstream chip movement.

2. A continuous chemical pulping process which comprises treating wood chips in a relatively weak alkaline black liquor at a temperature of about 200° F., draining said black liquor from the treated chips, saturating the treated chips in white liquor while gradually increasing the temperature of said white liquor, subjecting the treated chips to direct contact with steam to raise the chips to a cooking temperature, cooking the thus treated material under conditions of elevated temperature and pressure, diluting and cooling the pulp stock thus produced in a first washing stage with a filtered cooling liquor derived from a succeeding washing stage, diluting the plup stock after the first washing stage with white water in said succeeding washing stage, filtering said pulp stock, and passing the filtrate thus recovered to said first washing stage

to delute said plup stock entering said first washing stage, the chips moving essentially downstream through such saturating and subsequent steam contacting steps exposed to apertured conduit means, such process also including the steps of feeding such saturating liquor to the chips through the upstream end of such conduit means and feeding the steam to the chips through the downstream end of such conduit means and generally countercurrent to such downstream chip movement.

3. A continuous chemical pulping process which comprises treating wood chips in a relatively weak alkaline black liquor at a temperature of about 200° F., draining said black liquor from the treated chips, saturating the treated chips in white liquor while gradually increasing the temperature of said white liquor up to a temperature of about 290° F., subjecting the treated chips to direct contact with steam to raise the chips to a cooking temperature, cooking the thus treated material under conditions of elevated temperature and pressure, diluting and cooling the pulp stock thus produced in a first washing stage with a filtered cooling liquor derived from a succeeding washing stage, diluting the pulp stock after the first washing stage with white water in said succeeding washing stage, filtering said pulp stock and passing the filtrate thus recovered to said first washing stage to dilute said pulp stock entering said first washing stage, the chips moving essentially downstream through such saturating and subsequent steam contacting steps exposed to apertured conduit means, such process also including the steps of feeding such saturating liquor to the chips through the upstream end of such conduit means and feeding the steam to the chips through the downstream end of such conduit means and generally countercurrent to such downstream chip movement.

4. A continuous chemical pulping process which comprises treating wood chips in a relatively weak alkaline black liquor at a temperature of about 200° F., draining said black liquor from the treated chips, saturating the treated chips in white liquor while gradually increasing the temperature of said white liquor up to a temperature of about 290° F., subjecting the treated chips to direct contact with steam to raise the chips to a cooking temperature, cooking the thus treated material at a temperature of about 350° F. and steam pressures on the order of 120 p.s.i. gauge, diluting and cooling the pulp stock thus produced in a first washing stage with a filtered cooling liquor derived from a succeeding washing stage, diluting and cooling the pulp stock after the first washing stage with still cooler white water in said succeeding washing stage, filtering said pulp stock, and passing the filtrate thus recovered to said first washing stage to dilute said pulp stock entering said first washing stage, the chips moving essentially downstream through such saturating and subsequent steam contacting steps exposed to apertured conduit means, such process also including the steps of feeding such saturating liquor to the chips through the upstream end of such conduit means and feeding the steam to the chips through the downstream end of such conduit means and generally countercurrent to such downstream chip movement.

5. A continuous chemical pulping process which comprises treating wood chips in a relatively weak alkaline liquor, draining said relatively weak liquor from the treated chips, advancing the treated chips upwardly through a saturating zone while directing a cooking liquor into the mass of moving chips, subjecting said chips to steam while still moving through said saturating zone, transferring the steam treated mass to a digesting zone, moving the mass downwardly through said digesting zone while treating the same with a cooking liquor, diluting and cooling the mass leaving said digesting zone with a cooling wash liquor derived from a succeeding washing stage, introducing the diluted mass into a first washing stage, filtering off fibers from said first washing stage, passing the fibers thus recovered to said succeeding washing stage, washing said fibers with white water in said succeeding washing stage, and filtering the washed fibers, the chips moving essentially downstream through such saturating and subsequent steam contacting steps exposed to apertured conduit means, such process also including the steps of feeding such saturating liquor to the chips through the upstream end of such conduit means and feeding the steam to the chips through the downstream end of such conduit means and generally countercurrent to such downstream chip movement.

6. In a process of chemical pulping in which wood chips are saturated with a cooking liquor and then cooked at elevated temperatures and pressures, as defined in claim 5, the improvement comprising preconditioning said chips prior to saturating the same by submerging said chips in a relatively weak alkaline black liquor at a temperature on the order of 200° F.

7. A continuous chemical pulping process which comprises treating wood chips in a relatively weak alkaline black liquor, draining said black liquor from the treated chips, advancing the treated chips through a saturating zone, contacting said chips in said saturating zone with a white cooling liquor until the chips absorb about 14 to 18% by weight of active alkali, contacting the treated chips with steam to gradually increase thereof and to reduce the liquid to wood ratio, transferring the steam treated mass to a digesting zone, treating said mass in said digesting zone with a digesting liquor at elevated temperatures and pressures, and thereafter washing the digesting pulp, the chips moving essentially downstream through such saturating and subsequent steam contacting steps exposed to apertured conduit means, such process also including the steps of feeding such saturating liquor to the chips through the upstream end of such conduit means and feeding the steam to the chips through the downstream end of such conduit means and generally countercurrent to such downstream chip movement.

8. The process of claim 7 in which said pulp is washed in succeeding stages of successively decreasing temperatures and pressures.

9. The process of claim 7 in which the chips in said saturating zone are subjected to increasing temperatures and decreasing pressures as the treatment in said saturating zone progresses.

10. The process of claim 7 in which the temperature in the digesting zone is on the order of 350° F.

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