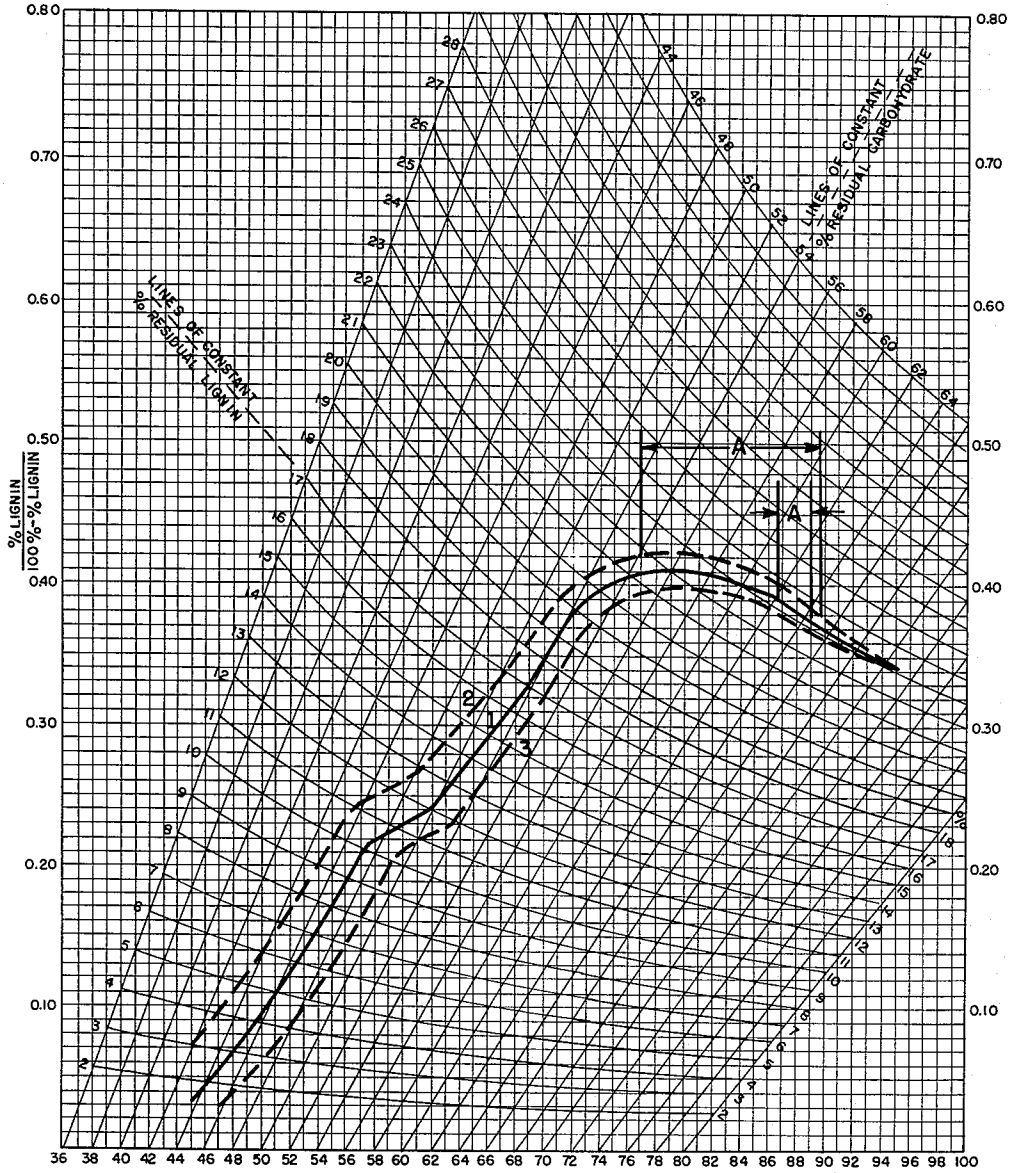
Aug. 15, 1961 L. G. DURANT ET AL 2,996,422

DIGESTION OF CELLULOSIC MATERIAL

Filed April 23, 1958 3 Sheets-Sheet 1

FIG. 1.



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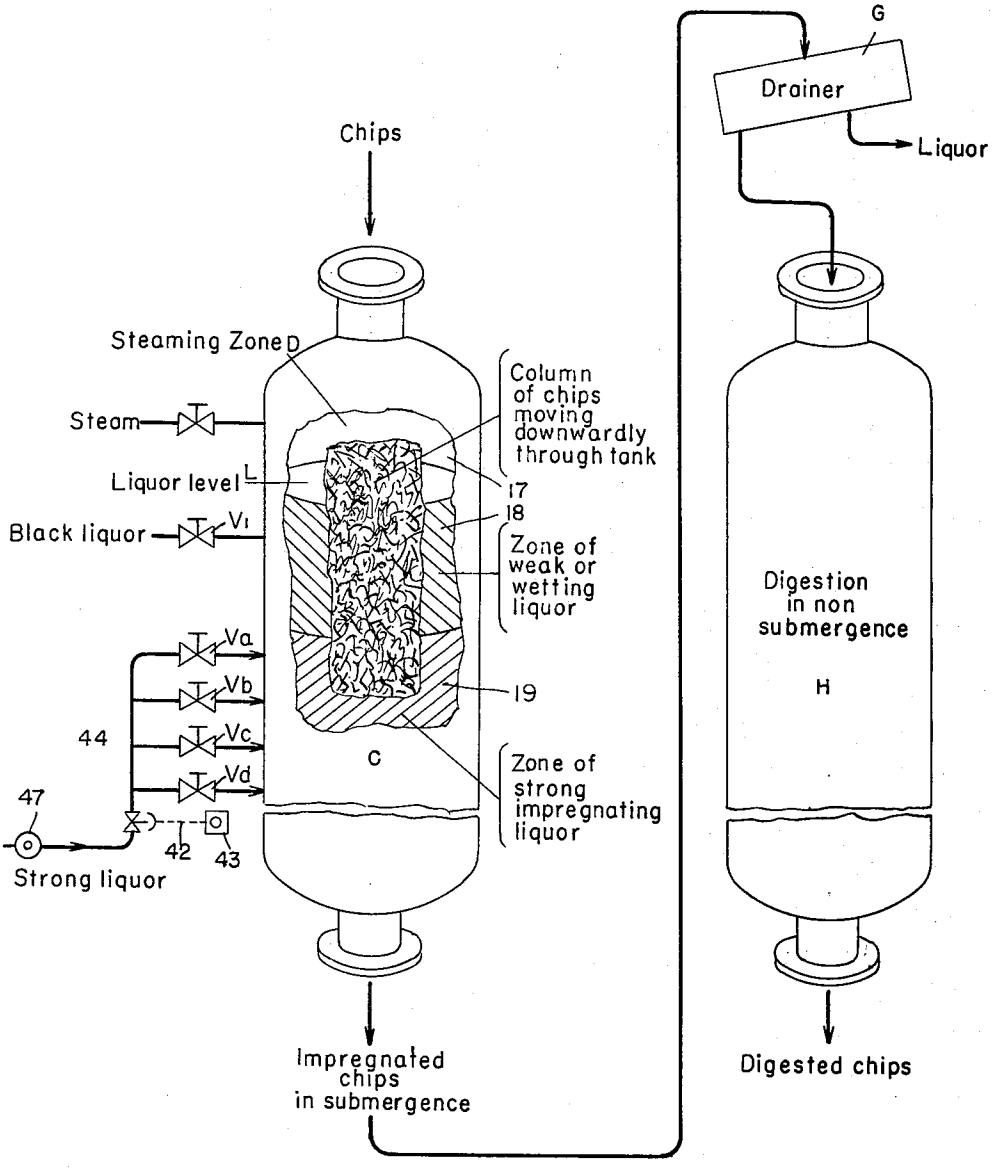
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DIGESTION OF CELLULOSIC MATERIAL

Filed April 23, 1958 3 Sheets-Sheet 2

FIG.2



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DIGESTION OF CELLULOSIC MATERIAL

Filed April 23, 1958 3 Sheets-Sheet 3

FIG.3

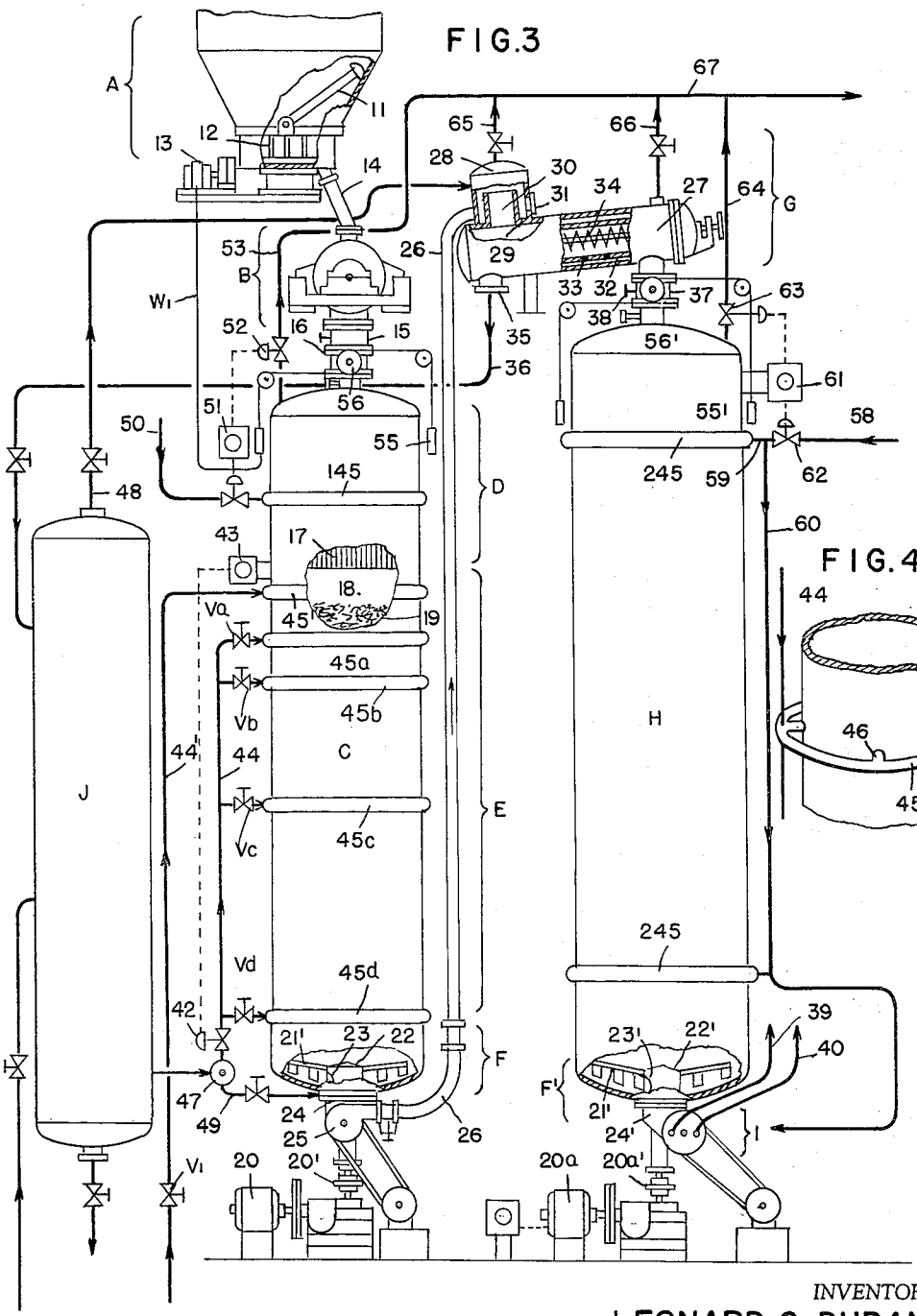


FIG.4

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2,996,422

DIGESTION OF CELLULOSIC MATERIAL

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Filed Apr. 23, 1958, Ser. No. 730,409
10 Claims. (Cl. 162—19)

This invention relates to the digestion of ligno-cellulosic material, exemplified by wood chips to render them more suitable for being yielded to semi-chemical or prime chemical pulps and more specifically to a method of subjecting such chips to a plurality of treatment zones, each of which renders the chips more suitable for further reaction in subsequent zones.

A new type of digestion system in treating wood pulps includes a primary enclosed tank or vessel wherein the chips in columnar formation are first steamed and then immersed in a pond of cooking liquor with which the chips are then impregnated. The chips from such an impregnator vessel are then evacuated therefrom, drained, and introduced into a cooking or digestion vessel where the chips are treated in a non-submerged condition to the further action of the impregnating liquid. Such a system is generally shown and described in FIGURE 1 of Patent No. 2,858,213 of October 28, 1958.

In the cooking of such wood chips one of the major problems is involved in removing undesirable lignin materials from the wood while at the same time retaining desirable carbohydrate materials such as pentosans. It is, therefore, the primary object of this invention to provide, in a continuous process digestion system, for the retaining of a higher amount of pentosans while removing the undesirable lignins in material such as wood chips, thus increasing the amount of pentosans retained for a given yield. Another object of this invention is to produce a higher grade of reacted wood pulp material while keeping the cost of the improved product well within competitive commercial ranges.

Another object is to incorporate in a continuously operable chip digesting system a series of treatment zones through which the chips are moved and which are adapted to be more closely controlled so that continuous amounts of pulp may be produced with relatively constant adherence to certain predetermined specifications.

Another object of this invention is to control during the critical period at the start of wood chip digestion the amount of pentosans which are removed therefrom while simultaneously providing a method and apparatus for retaining more of these desirable pentosans than was heretofore possible in continuously operable systems.

It is well known that both lignins and carbohydrates, including pentosans, are removed from wood chips by the action of an alkaline cooking liquor acting on the wood chips at elevated temperatures.

It has been noted in the digestion of wood chips that the pentosans are removed by the alkaline cooking liquors at elevated temperatures and will start to be removed earlier during the process than the lignin material therein. It has been determined that a particularly critical period for undesirably removing pentosan is near the start of the cooking procedure when the cooking chemical is first introduced to the chips. In "batch" processes, used until the recent development of the continuous process, cooking liquor is introduced at very low temperatures in order to retard the action of the chemicals so as to retain pentosans while the chemical is being completely diffused within the chip, at which time it can begin action on the lignin materials. Then the temperature is allowed to come up to maximum for cooking and in this way the ratio of the loss of pentosan to the loss of lignins has been controllable to a certain extent.

In following this procedure with continuous equipment difficulties were encountered in that restrictively long periods of time were necessary and prohibitive amounts of expensive equipment were required. It was necessary, therefore, in order to allow the use of continuous equipment of practicable and economical size to find a new way to accomplish this "delay of reaction" in order to prevent the early release of pentosans in amounts which would contribute to the degradation of the pulp product.

Applicants have found that steam at elevated temperatures can be used in the early part of the process without releasing an uncommon amount of pentosans provided that thereafter water or black liquor is used to wet the wood. This "black liquor" may be either the diluted product obtained from previous utilized amounts of cooking liquor or may be new liquor in considerably weaker concentration of alkali, such as Na_2O. After the steamed wood chips are wetted thoroughly, and then moved through a new and stronger concentration of cooking liquor, the wetness of the chips promotes a rapid diffusion of the stronger chemical throughout the chip. This wetness is simultaneously keeping the chemical within the chip sufficiently diluted throughout the critical period so that there is far less reaction of the alkali on the pentosans in the hot chips than there would be if normal cooking liquor of higher concentration were applied directly to the chip at their initially elevated temperature.

In other words applicants have found that there can be substituted in the continuous digestion process a practicable decrease in temperature from that of superatmospheric steam and concurrent rise of concentration of cooking liquor within the chip in place of the slow rise to temperature as used in conventional batch type systems, thus establishing a practical and economical cooking system resulting in superior grades of pulp.

Emphasizing the major concept of the present invention there is provided in the same vessel or enclosure an overlying superatmospheric pressure steam layer and a subjacent layer of cooler strong, concentrated cooking liquor, an intermediate wetting layer containing weak (black) liquor or water which has also been found to be highly advantageous when the chips are subsequently and separately digested in non-submergence.

Referring now to the drawings:

FIG. 1 is a graphical representation of the superior pulp yields which may be realized through the utilization of this invention.

FIG. 2 is a diagrammatic showing, with legends, of the main steps of the process of this invention.

FIG. 3 is a diagrammatic side elevation with some parts shown in section of a continuous digestion system that forms the environs of the invention.

Ross diagram

Before proceeding with a description of the process and apparatus shown in FIGURES 2 and 3 of the drawings, reference will be taken first to the showing of FIG. 1 wherein a Ross diagram is shown with the horizontal lines representing the percent of lignin, the vertical lines representing the yield in percent realized during various stages of the cooking process, the slanted lines represent lines of constant percent of residual carbohydrates and the curvilinear lines represent, as labeled, lines of constant percent residual lignin.

Referring specifically to the curves represented on the graph, curve 1 of this Ross diagram shows a typical curve for a desired yield of pulp cooked under the best conditions noted present as the progression of normal cooking of wood chips with kraft cooking liquor proceeds. Curve No. 2 shows what happens with regard to yield, lignin, and carbohydrate percentages when a cook is made under

like conditions of temperature, time, pressure, etc. but with liquor of stronger chemical concentration. Curve 3 represents the result of the controlled application of a lower concentration of cooking liquor immediately after the chips leave the steaming zone and before they get to the zone of strong impregnating liquor, in conformance with the precepts of the present invention.

Experimentation has shown that in the areas of each curve marked A, substantially only pentosans are being removed from the wood chips. In the case of curve 1, this period is relatively short so that only a small amount of pentosans are removed. In the case of curve 2 the period A is considerably extended and a larger amount of pentosans are indicated as being removed from the chips. The end result is that curve No. 2 indicates a final pulp of higher objectionable lignin content for a given degree of yield. It is noted that in curve 2 the pentosan removal continues all the way down to the 77% yield and that all during this time only about 1.2% of lignin has been removed. Normal pulps such as depicted by curve No. 1 will contain desirable pentosans in amounts of about 6 to 8%. Experiments have shown that pulps that are depicted by curve No. 2 have substantially lower pentosan contents of from 3% to 4.5%. While the lower parts of curves 1 and 2 are approximately parallel, the damage i.e. pentosan removal, has already been done with the result that there is a loss of yield on the wood, largely because of the excessive original loss of pentosans. Thus, the loss in yield is actually loss of a desirable component in the final product.

Curve No. 3 shows some points obtained on a series of cooks wherein wood chips were subjected to a preliminary bath of black liquor (weak in concentration) and then to a bath of normal concentration cooking liquor. The chemically weak black liquor protected the wood from the drastic results of alkali attack on the wood during the early rise to temperature, before subjection to the stronger liquor necessary to complete the cook. This shows that greater yields are obtainable in this matter for the same amount of lignin removable which in turn indicates that there is a retention of desirable pentosan material and other carbohydrates while undesirable lignins are removed.

Thus, comparing the curves at an arbitrary yield selected at 50% we see that a normal cook would yield approximately 9.5% of lignins, while a cook completed using higher temperatures or higher concentrations would result in a product containing 14% lignin. In a cook conducted according to the present invention, it is seen that for the given yield of 50% there is a decrease in the amount of undesirable lignin remaining, in that only approximately 6% of lignin was retained. Projecting curve 3 on up to the end point it will be realized that applicants' system of wood chip cooking has resulted in a much smaller amount of pentosan removal in the critical early stages of the cook, this result manifesting itself in a much lower lignin content in any given final yield selected.

Referring now to FIGURE 2, there is shown therein the utilization of applicants' invention in a continuous process digestion system, which is more specifically described in connection with FIG. 3. It is noted in connection with FIG. 2 that the chips are introduced into the impregnating vessel and are immediately subjected to a steaming zone containing steam at super atmospheric pressure, after which they are submerged in a zone of cooler weak or wetting liquor which may be either water or black liquor as described hereinabove, which serves to further wet the chips coming from the steaming zone. After the chips move downwardly through the zone of weak or wetting liquor, they are immediately introduced into the zone of strong, impregnating cooking liquor of full normal strength, from which they are, after a suitable period of time, removed and drained of excess liquor before they are introduced into the digestion vessel.

The wood chips remain in the steaming zone for a maximum of approximately five minutes, the super atmospheric pressure helping to remove the air from within the chip since air is being constantly replaced by condensed steam (moisture). By removing and compressing the air from within the chip a serious impedance to the penetration of liquid is effectively removed, so that the chip is ready to rapidly accept liquid.

It is important to note that if the steaming were continued, it would take about ten minutes for a maximum possible amount of water to become condensed in the chip, the chip simultaneously rising in temperature because of the incoming steam with the following undesirable effects taking place:

(1) Less than a maximum amount of moisture will accumulate in the chip because the chip becomes too hot to allow the steam to condense, and

(2) The temperature within the chip will promote hydrolysis of the wood which in turn will degrade the final pulp.

Therefore, in order to get a maximum amount of liquid into the chip without exposing the wood to the above undesired conditions, it is necessary to subject the wood to a liquid bath, or intermediate zone of weak or wetting liquor. The chips, having been prepared by superatmospheric steaming absorb this liquid quite rapidly in from 2 to 4 minutes, during which time the chip temperature is not increasing because continuously supplied liquid rather than incoming steam is being used. At the same time, no drastic reactions as mentioned in 1 or 2 above are occurring.

With the chip having absorbed a maximum amount of liquid (about 2:1 liquid to wood ratio) the chip is now ready to receive the chemical which will diffuse rapidly throughout the chip because of the presence of the wetting liquid. The use of low chemical concentrations during all of this time simultaneously assures that no drastic chemical attack will take place on the pentosans in this critical early period of contact of the wood chip with the chemical liquor.

Experience with various kinds of woods has shown that the following times of residence in each of the zones is most advantageous:

	Steaming Time, minutes	Total Time of Residence or of Transit of a Columnar Chip in Submergence, minutes	Time through Wetting Zone, minutes	Time through Impregnating Zone, minutes
1. Soft wood Kraft	3-5	12-15	2-3	10-12
2. Hardwood Kraft	3-5	15-18	3-4	12-14
3. Neutral Sulphite (Bleaching grade)	3-5	18-21	3-4	15-17
4. Soft wood Sulphite	3-5	20-25	3-4	17-21
5. Hi-yield Sulphite	3-5	17-21	2-4	15-17

Description of apparatus

Referring now to FIG. 3 of the drawings showing the environmental system, there is a chip bin A for receiving chips, or other cellulosic materials to be treated, an arch-breaker **11**, and a suitable rotary chip-discharging mechanism **12**, operated by a variable speed motor-driven mechanism **13**, which passes chips downwardly through the feed pipe **14** at a regulatable rate into a multivane chip feeding mechanism B for delivering chips through pipe **15**, valved as at **16** to and into a primary enclosed chamber shown as cylindrical tank or vessel C having an overlying or upper steaming zone D having a steam atmosphere **17**, and a subjacent bath or pond with a liquid-level L comprising a lower impregnating zone E made up of a wetting zone **18** and a strong liquor impregnating zone **19**. While zones **18** and **19** are shown as having a somewhat definite line of distinction therebetween, it should be recognized that the weak or wetting liquor making up zone **18** flows downwardly and therefore continuously dilutes the liquor of zone **19** which is also being constantly replenished by strong liquor through the outlet rings **45***a*,

45*b*, 45*c*, 45*d*, which are supplied by pipe 44 through valves V*a*, V*b*, V*c*, V*d*. The weak or wetting liquor, which may be either water or diluted liquor, enters the wetting zone 18 through an annular ring 45' which is similar to annular rings 45*a* through 45*d* and which is supplied by a pipe 44' valved at V_1, directed to ring 45' from a suitable source of wetting liquor, not shown. In the bottom of tank C (sometimes called the impregnator vessel or zone) there is an evacuator mechanism F for accomplishing continuous discharge of chips from the column thereof in the tank by means of a motor mechanism 20 driving a shaft 20' that moves in circular paths blades depending at a chip impelling angle from arms 21 extending radially from a shroud 22 providing a dome covered vertical cylinder rotating with the blade bearing arms 21' and having a door-like opening 23 in the vertical cylinder through which blade impelled chips are passed downwardly through pipe 24 into pump 25 that forces the chips while submerged in cooking liquor and under pressure up through delivery conduit 26 to deliver them under pressure tangentially to a drainer station G that comprises an outer inclined steam tight cylindrical tank 27 having a steam dome 28 with an annular bottom 29 from which uprises a stack 30 down which fall chips and liquor tangentially to the steam dome 28 by the delivery conduit 26. The chips and liquors swirl upwardly to spill over the upper weir-like edge of the stack 30 but meanwhile tramp metal or other detritus gravitates to the annular bottom 29 from which it can be removed through an aperture such as 31. Above the bottom of the inclined tank 27, there is an inner tank or cylindrical drainer 32 having perforations 33, and rotatable therein is a screw conveyor 34. Thus, chips and liquor descending through stack 30 enter drainer 32 up which the screw conveyor 34 moves them while their liquor drains from them through the perforations 33 and flows from the tank through outlet 35 and pipe 36 for recovery treatment such as in accumulator tank J. The chips that are so drained of the cooking liquor while retaining their absorbed and adsorbed liquor pass downwardly through pipe 37, valved as at 38, into an enclosed chamber shown as cooking or digestion tank or zone H where the chips are digested in non-submergence but in the presence of steam and their own adsorbed and absorbed liquor. After being properly digested, they are removed from the entire cross sectional area of the bottom of the digester tank or zone H by another evacuator mechanism F' (like station F) by means of a motor mechanism 20A driving a shaft 20A', that rotates blade bearing arms 21' extending radially from a shroud 22' having an opening 23' therein through which chips are passed downwardly through pipes 24'. These primed numerals represent parts identical with their unprimed corresponding numerals described in connection with evacuator station F. But here pipe 24' leads into an axial flow ejector station I from whence, through pipes 39 and 40, digested chips are blown by a steam stream to further treatment such as into a blow tank from which they go to refining or any other desired treatment. Since it usually becomes important to reclaim or otherwise control the cooking liquor used, J, indicates an accumulator tank or station. Cooking liquor of controlled strength is pumped by pump 47 from the tank J through a suitable valved liquor inlet line 44 described hereinabove. This pipe 44 has connected therein a conventional automatic valve 42 controlled and regulated by a differential pressure type recording controller 43 for regulating the elevation of the liquid level L of pond 18 of cooking liquor so that it is maintained constant, or at least as nearly so as possible. So the automatic valve 42 regulates the flow of liquor through pipe 44 and its branches, each of which leads into an annular manifold 45 having injection nozzles such as at 46 (see FIG. 4) extending therefrom into the tank C, whereby liquor can be forced into the tank in a fairly well dispersed or distributed manner. The manifolds 45 and 45' are distributed along the tank C as may seem desirable. Another pipe 49 also leads from the accumulator tank J and goes to and into the pipe 24 leading to pump 25 for giving control of the quantity of liquor mixed with the chips discharged from tank C by evacuator F to make them pumpable (at a consistency of say 10%) by pump 25 up through pipe 26 to the drainage station G. An equalizing pipe 48 is used to lead from the top of the accumulator tank J upwardly to the steam zone 28 of the drainage station G. This permits the use of similar pressures throughout the equipment and eliminates the need for valved off sections in order to maintain different temperatures therein. Thus, liquor can be heated outside the vessel (C) and introduced at a temperature of, e.g., 120° C. while steam can be maintained at a temperature of 175° C. in the steam zone at a corresponding pressure. The liquor, since it continuously moves downwardly after introduction is only in contact with the steam zone for a fraction of a second as is not appreciably heated thereby. Other valved pipes leading into the accumulator tank J are for conducting certain incoming chemical bearing fluids thereinto and for discharge therefrom.

From any suitable source, steam under pressure is supplied through steam inlet line 50 through the steaming zone D in the primary tank C by means of an annular manifold ring 145 in all respects like rings 45' and 45*a* through 45*d* and having the same kind of injection nozzles 46 (see FIG. 4) to supply steam into the tank, in a well distributed manner. The inlet of steam into the manifold 145 is controlled and regulated by conventional pressure-temperature recording controller 51, that also controls and regulates valve 52 in vapor outflow line 53. And a final control is indicated generally at 55 that is a chip level gauge and controller that consists of a transmitter containing a radioactive material, and a receiver is connected electrically by connection W1 to the motor drive 13 of chip discharger 12, to automatically regulate the chip level to be substantially constant. The instrument is so mounted that the "set point" can be lowered or raised such as by pulley 56 by the operator. These radiation measuring and monitoring devices are made by the Ohmart Corporation of Cincinnati, Ohio. A similar chip level sensing gauge in controller 55' is applied to the digestor zone or tank H, with its raising and lowering pulley 56' but in this case the controller 55' regulates the motor drive 20, the evacuator station F on the primary vessel C.

Digester zone or station H is provided with a steam inlet line 58, for delivering steam under pressure to the branch lines 59 and 60 each respectively feeding steam to annular manifold rings 245 having injection nozzles, patterned after rings 45' and 45*a* through 45*d*, with nozzles 46. Inlet of steam through line 58 is controlled and regulated by a conventional pressure temperature recording controller 61 (similar to controller 51) operating an automatic valve 62 and also an automatic valve 63 included in vapor outflow line 64. Valved vapor outlet or gas-off pipe 65 from the steam dome 28 of the drainage station G, and also from valved vapor outlet or gas-off pipe 66 from the high point of the inclined tank 27 of that station, can all join into a common exhaust or gas-off line 67 leading to further treatment of the vapors, as desired, such as for turpentine recovery.

The continuous digestion of cellulosic material such as wood chips carried out by this system in successive treatment zones may be said to comprise feeding chips continuously to the steaming zone where, in columnar formation, they are prepared for the ready acceptance of the wetting and cooking liquors by appropriate steaming thus releasing non-condensable gases and otherwise preparing the chips for ready acceptance of the liquor; next submerging the thus conditioned chips in cooler but hot wetting liquor, which may be either weak or "black" liquor or water, under controlled conditions of time and

temperature that assures complete penetration and diffusion of the wetting liquor into the chips and limits the chemical reaction therebetween so that in this zone of wetting treatment there is minimized any fiber degrading action; next subjecting the chips to the action of a strong impregnating liquor of much higher chemical concentration, this impregnating liquor being readily diffusible into the chips by reason of the already wetted condition produced by the action of the wetting liquor thereon. The chips themselves now contain an amount of absorbed and adsorbed liquor of controlled chemical concentration sufficient to be cooked rapidly but insufficient to cause cellulose degradation, so they are transferred while in submergence and still under pressure from the impregnation zone to a drainage zone where they are relieved of their excess liquor which drains freely therefrom during their upward conveyance along the perforated cylindrical drainer. The drained chips are then cooked while in downwardly moving columnar formation in only their retained liquor and in non-submergence in a gaseous or steam environment enclosed in a digester vessel. After being so cooked, the chips are evacuated from the digestor into an ejection zone having a receiver for the digested chips, from whence digested chips are ejected while in suspension in a stream of chip blowing steam and projected or blown to a place of subsequent treatment. All of the action steps are carefully controlled as to pressure, temperature, and the rate of downward movement or the time of transit of the chips through each treatment zone and between such zones, which is a reason why the chip level is maintained substantially constant in each of the vessels C and H and the temperature and pressure of the steam is also carefully automatically controlled.

Process steps and operation

For the sake of further clarification and understanding of the invention, the process will now be followed through the equipment. Starting with wood chips which are introduced into the impregnating vessel by way of the chip bin A and the rotary injector units, the chips are first introduced into the area D in the impregnating vessel which contains steam at superatmospheric pressure supplied through pipe **50** and distributed into the vessel by ring **145**. This steaming procedure takes from three to five minutes depending on the type of wood, the chip level, the amount of moisture; the liquid level and speed of put-through being controllable. Thus, the operator has only to set the equipment, for example, for five minutes steaming of the chips before they enter the liquor bath. The wood will automatically absorb moisture and release air due to the operation of the pressurized steam thereon, and no further controls at this point are necessary. It is noted that more than five minutes steaming may produce hydrolysis of the wood chip, so the steaming time is limited to five minutes regardless of whether the chip has absorbed maximum water content, which has been determined to be approximately a 2 to 1 liquid to wood ratio.

Prior experimentation has determined that the chips are in fact not up to maximum absorbed liquid content when they pass through the steam zone and are in a condition to accept further liquid rapidly. Therefore, as they are introduced into the weak liquor or water area **18** in the cylinder through interface L, the fluid material contained therein will further impregnate the chips, this impregnation being aided by the steamed condition of the chips. It is noted at this point that the weak liquor or water added through ring **45'** supplied by pipe **44'** will find its way into the next layer of stronger liquor which is being added through each of the rings **45***a* through **45***d* supplied by pipe **44**. However, this weak liquor or water supply is being continuously replaced so that the top layer of liquid in the impregnated vessel is always weak in chemical concentration (not over 10 grams per liter of alkali for example, if the weak liquor used is kraft black liquor). The volume of liquid which is being injected into the vessel through the rings is constantly being controlled by automatic controllers and the height of the total liquid is, therefore, being controlled. It should be noted that the rate of downward movement of the chips through the liquid is also being controlled by automatic devices as mentioned above.

The chips after steaming will absorb a certain amount of liquid in approximately two minutes or less, depending on the wood. If the chips are held in this weak liquid or water for more than the time necessary to allow maximum water or liquor absorption to take place, no damage to the chip occurs. However, if the chips are held in the weak or wetting liquor zone for too short a time, damage to the chip may occur because of chemical reactions which take place later in the process, i.e. action of strong liquor at high temperature upon unwetted portions of the wood chips, thus causing immediate reaction therewith and degradation of the eventual quality of the pulp produced. The equipment has, therefore, been designed so that it can be automatically controlled to allow chips to take three minutes or even four passing through the wetting liquor A.

The next problem is to get sufficient chemical in the chip to make the cook complete. It has been determined from past history and experiment that it will take from about 15.5% to 16% of effective alkali (for instance in kraft) to complete the cook. We also know that it will take approximately ten to twelve minutes holding time to diffuse the chemical into the wood in the strong liquor zone. Also it has been determined that the ratio of final concentration to initial concentration in the impregnator after impregnation will be about 65% when a ratio of total liquid to wood of 8 to 1 is used.

Therefore, we start out with liquid and wood after initial soaking in wetting liquid in the ratio of 2:1. The chips are now passed through a chemical bath in which there is a total liquid to wood ratio of 8:1. In other words chemical solution is added in the amount of six parts of solution to each part of dry wood.

If this chemical solution contains 75 grams per liter of alkali (as Na_2O) and the final concentration is expected to be 65% of the initial concentration, and the wood will absorb a liquid to wood ratio of 2:1, it will be seen that if six parts of solution at 75 grams per liter are added, 450 grams of chemical will be required. The solution at the end of diffusion time is 65% of original strength, so 75 times .65 equals 48.8 gallons per liter. Since two parts of liquid are in the wood already, the total chemical amount in the wood is 6×48.8 or 292. Therefore, the chemical in the wood then is 450 grams minus 292 grams which gives the amount of chemical finally in the wood at 158 grams or 15.8%. This is the amount of chemical needed to complete a kraft cook for easy bleaching. The same principles exist for other kinds and qualities of pulp although not necessarily the same amount of chemical requirements, which may vary slightly according to the wood used and end product desired.

The excess chemical solution is now drained off of the chips through the drainer section G and the chips are introduced in the cooking vessel H where they will be cooked for about thirty minutes at about 178° centigrade in this digestor portion. It is noted that here again other types of pulp may require slightly different cooking temperatures and time but in any case the time needed for this process is short in comparison with other methods now used to produce prime grades of pulp.

As this invention may be embodied in several forms without departing from the spirit or essential characteristics thereof, the present embodiment is therefore illustrative and not restrictive since the scope of the invention is defined by the appended claims and all changes that fall within the metes and bounds of the claims or that formed their function as well as cojointly co-oper-

ative equipments, are, therefore, intended to be embraced by those claims. For instance, whereas the treatment of wood chips has been described, it should be understood that other lignocellulosic particles and material could be substituted therefor which are desired to be exposed to continuous type digestion processes.

Having thus described our invention what we claim is:

1. In the continuous digestion process of treating ligno-cellulosic material exemplified by wood chips, which is characterized by impregnating the chips in an impregnating vessel, evacuating the chips therefrom and draining them of excess liquor, moving the chips into a digestion vessel from which they are removed for further processing, the improvement which consists of the steps of subjecting a continuously moving column of chips to steam at superatmospheric pressure for not more than five minutes, causing the steamed chips to pass through a bath of wetting liquor, cooler than said stream, selected from the group consisting of water and black liquor for a time sufficient to substantially completely saturate the chips with said wetting liquor, followed by continuously passing the column of chips through a bath of impregnating cooking liquor, stronger than said wetting liquor, for a time sufficient to replace the wetting liquor with stronger impregnating liquor, before the chips are drained and introduced into the digestion vessel.

2. The process of preparing ligno-cellulosic material of digestion which comprises the steps of downwardly moving the material in a single vessel to subject it sequentially to steam at superatmospheric pressure for from three to five minutes to remove gases contained therein and to partially saturate the material with moisture, then to and through a wetting liquor, cooler than said stream, selected from the group consisting of water and black liquor for a period of from two to four minutes, and next to and through a strong cooking liquor, stronger than said wetting liquor, for a period of from ten to seventeen minutes, all prior to draining the material and digesting it in another vessel at elevated temperatures.

3. The process of preparing soft wood kraft material for digestion which comprises the steps of downwardly moving the material in a single vessel to subject it sequentially to steam at superatmospheric pressure for from three to five minutes to remove the gases contained therein and to partially saturate the material with moisture, then to and through a wetting liquor, cooler than said stream, selected from the group consisting of water and black liquor for from two to three minutes, and next to and through a cooking liquor, stronger than said wetting liquor, for from ten to twelve minutes, all prior to draining the material and digesting it in another vessel at elevated temperatures.

4. The process of preparing ligno-cellulosic material for digestion which comprises the steps of downwardly moving the material in a single vessel to subject it sequentially to steam at superatmospheric pressure, immersing the steamed material in a wetting liquor, cooler than said stream, selected from the group consisting of water and black liquor, and then immersing the material in a cooking liquor, stronger than said wetting liquor, all before the material is drained of liquor and digested in another vessel at elevated temperatures, the material remaining in each of the steaming, wetting, and cooking baths for a period of time sufficient to produce a yield which is substantially the same as that denoted by curve 3 of the accompanying Ross diagram.

5. The continuous digestion of ligno-cellulosic material such as wood chips which comprises maintaining a steam-bearing digestion enclosure in which such chips after initial separate liquor impregnating treatment are digested in non-submergence with the only cooking liquor being that carried into the enclosure by the chips themselves, removing digested chips from the digestion enclosure, and supplying to that enclosure chips prepared as follows: maintaining a chip-impregnating enclosure with an overlying layer of super-atmospheric steam, maintaining a constant level subjacent bath having a top layer of liquor at a temperature cooler than the steam but at least 100° C. and at a sub-normal chip-cooking strength for merely wetting the steam chips, maintaining beneath that top layer of cooler weak liquor a layer of stronger liquor at normal cooking strength, moving a column of chips downwardly through the impregnation enclosure and through its sequential layers at a rate to transit the steam layer therein in not more than five minutes and through the stronger liquor layer therein at a rate so that the chips absorb sufficient cooking liquor to enable them to be completely digested in non-submergence in the digestion enclosure when transferred thereinto in drained condition, whereby loss of pentosans from the chips is minimized by moving the chips downwardly through the respective layers in the impregnation enclosure to encounter (1) maximum temperature in the steam layer and in the succedent liquor layers lower temperature than said maximum temperature and (2) weak liquor in the top liquor layer increasing to full cooking strength therebelow.

6. The continuous process of preparing ligno-cellulosic material such as wood chips for digestion to render ligneous material thereof readily removable while assuring certain desirable components thereof such as the pentosans against removal, which comprises maintaining in a vertically elongated enclosure that is a chip-impregnation vessel having an overlying layer of super-atmospheric steam and a subjacent bath of liquid at a temperature less than the steam but at least 100° C., whose liquid level is maintained substantially constant, adding to and maintaining in the uppermost section of the bath in the impregnation vessel a chip-wetting layer of weak liquid chosen from a group consisting of water and black liquor, adding incrementally to subjacent sections of the bath active cooking liquor to form in the bath a layer thereof of normal cooking strength, moving a column of wood chips at a controlled rate downwardly through the impregnation vessel so that chips of the column pass downwardly in the same enclosure sequentially through the respective layers in a time of transit of not more than five minutes through the hotter steam layer and of from 12 to 25 minutes through the subjacent liquid layers depending upon the kind of wood being treated which latter time is divided into not substantially more than four minutes for the cooler weaker wetting layer, and the remainder of the time for the stronger liquor layer.

7. The continuous process of digesting ligno-cellulosic material such as wood chips by which ligneous material thereof is rendered readily removable while assuring certain desirable components thereof such as the pentosans against removal, which comprises maintaining in a vertically elongated enclosed chip-impregnation vessel an overlying layer of super-atmospheric steam and a subjacent bath of liquid at a temperature less than that of the steam but at least 100° C., whose liquid level is maintained substantially constant, maintaining a separate elongated steam-bearing enclosure that is a digestion zone, conveying impregnated chips to the digestion zone, transiting the chips therethrough in non-submergence whereupon the digested chips are removed, adding to and maintaining in the uppermost section of the bath in the impregnation vessel a chip-wetting layer of liquid chosen from a group consisting of water and black liquor, adding incrementally to subjacent sections of the bath active cooking liquor to form in the bath a layer thereof of normal cooking strength, moving a column of wood chips at a controlled rate downwardly through the impregnation vessel so that chips of the column pass downwardly through the respective layers in not more than five minutes for the hotter steam layer and not substantially more than four minutes for the weaker wetting layer, but for the stronger liquor layer a time long enough for the chips to absorb

enough cooking liquor so that they contain enough without further addition in the digestion zone to cook properly therein, which time depending upon the wood used is usually not over 21 minutes.

8. The continuous process of preparing ligno-cellulosic material for digestion to render its ligneous material readily removable while assuring certain desirable components such as the pentosans against removal, which comprises maintaining in a vertically elongated enclosure impregnation vessel an overlying layer of super-atmospheric steam at substantially 175° C. and a subjacent bath of liquid at substantially 120° C. whose liquid level is maintained substantially constant, maintaining a further elongated steam-bearing zone that is a digestion zone which contains no liquid bath, adding to the bath in its uppermost section as a wetting liquid layer in the bath wherein the steamed chips are first received, a chip-wetting liquid chosen from a group consisting of water and black liquor, adding incrementally to subjacent sections of the bath lignin-digesting strong liquor to form in the bath a layer thereof of normal cooking strength, moving a column of ligno-cellulosic material such as wood chips downwardly through the impregnation vessel at a controlled rate, to pass downwardly through the layers in not more than five minutes for the hotter steam layer, not substantially more than four minutes for the cooler weaker wetting layer, and from 10 to 21 minutes for the stronger liquor layer depending upon the material to be digested, conveying chips to the steam-bearing digestion zone while impregnated with enough digesting liquor so that they need no more, and digesting the chips therein in non-submergence whereupon the digested chips are removed.

9. A continuous process of digestion of ligno-cellulosic material such as wood chips in which the material continuously descends in a self-supporting column in a chamber in which super-atmospheric steam is maintained in the upper part and hot cooking liquid is maintained in the lower part, the material and liquor are withdrawn continuously from the chamber, the material is drained and then subjected to hot gas in a column in a second chamber, characterized by continuously injecting into the upper part of the body of liquid in the first chamber a liquid of weaker concentration than the hot cooking liquid, this weaker liquid being drained from the material only in admixture with the hot cooking liquid.

10. A continuous process of digestion of ligno-cellulosic material such as wood chips in which the material continuously descends in a self-supporting column in a chamber in which super-atmospheric steam is maintained in the upper part and hot cooking liquid is maintained in the lower part, the material and liquor are withdrawn continuously from the chamber, the material is drained and then subjected to hot gas in a column in a second chamber, characterized by continuously injecting into the chamber near the steam-liquid interface a liquid of materially weaker chemical concentration than the cooking liquid below the region of injection of the weaker liquid, so that in the same chamber a chip passes from steam first into weaker, then into stronger liquid, the super-atmospheric pressure of the steam being transmitted to the stronger cooking liquid through the intervening weaker liquid, to suppress vaporization of the cooking liquid.

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