PROCESS FOR THE CONTINUOUS DIGESTION OF CELLULOSIC MATERIALS

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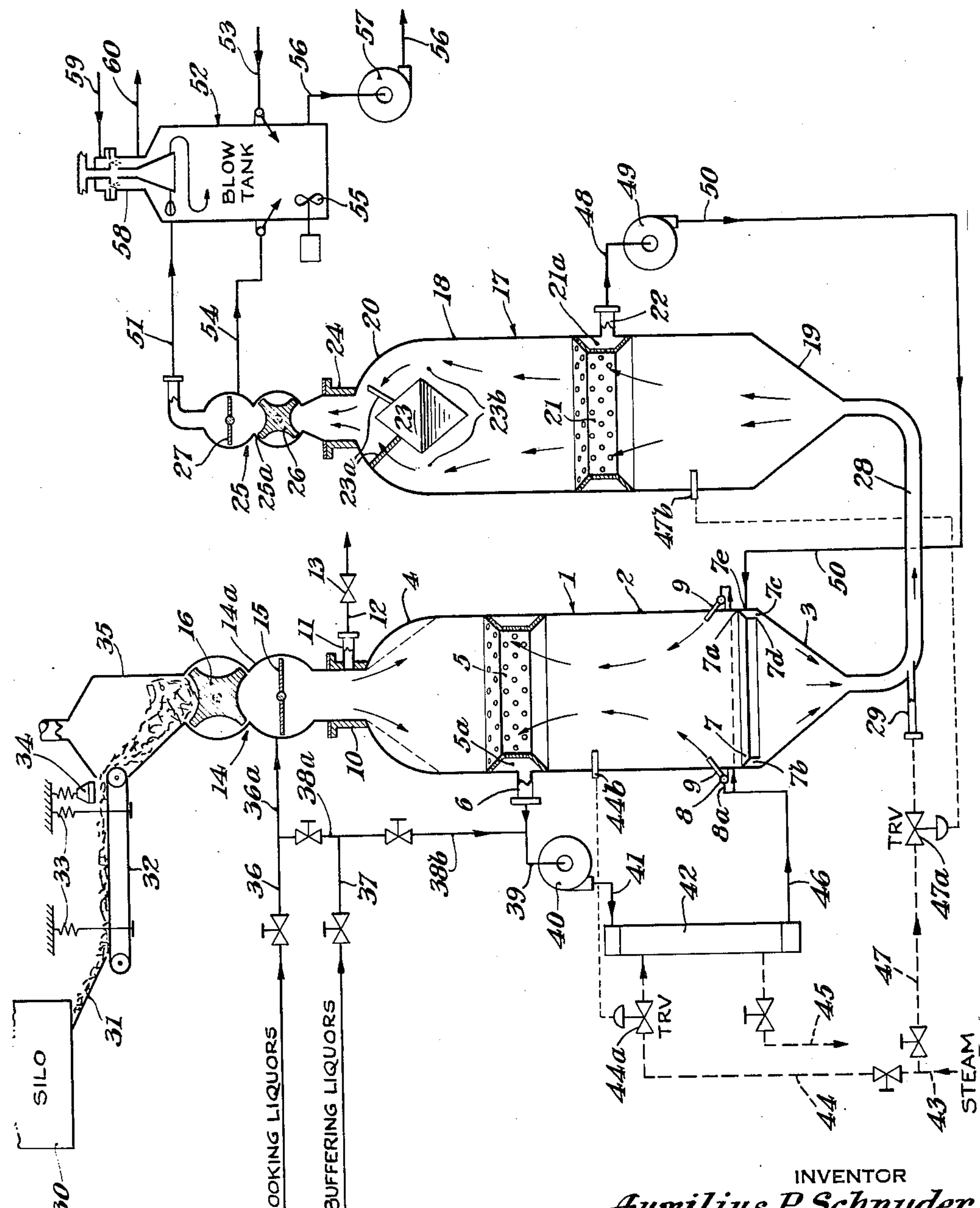

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PROCESS FOR THE CONTINUOUS DIGESTION OF CELLULOSIC MATERIALS

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This invention relates to pulp preparation and more particularly to an improved process for effecting the continuous digestion of cellulosic materials and apparatus therefor.

At the present time the digestion of cellulosic materials is primarily carried out utilizing either soda, sulfate, sulfite or neutral sulfite processes and is primarily performed by batch methods; i.e. the cellulosic materials in relatively small pieces or chips and delignifying chemicals in aqueous solution are charged into a pressure cooker or digester wherein the mixture is raised to delignifying temperatures and thereafter discharged as concentrated pulp and spent liquor to further processing operations. Processing data for determining delignifying conditions, such as strength of the chemicals, time and temperature, is determined to a great extent from actual experience rather than from correlated laboratory data, since the severity of the chemical attack on the charged cellulosic materials varies considerably even within wood species.

The reluctance of the paper industry to convert to a continuous digestion process is for the most part based on the cost of new equipment for such process rather than on the economics of the process per se, since the new equipment for a continuously operated process would render obsolete operable batch equipment. Further, existing batch-wise operated plants have been enlarged to such an extent that certain benefits of continuous operation have been realized.

Proponents of continuous processes have long recognized that continuous process techniques when applied to the preparation of pulp, would inherently have numerous advantages over existing methods, namely:

(A) An overall continuous process from the introduction of raw cellulosic materials and delignifying chemicals to the finished product;

(B) A reduction of steam requirements;

(C) An improved pulp yield from the raw cellulosic material, including uniform pulp quality;

(D) A reduction of heat losses;

(E) Improved heat recovery systems utilized for maximum heat recovery from blown digested pulp stock;

(F) Reduced labor and operating costs; and

(G) Elimination of the time required for charging and blowing digesters.

The need for a continuous process for the digestion of cellulosic materials has resulted in many inventions, however few have attained commercial success and then only to a limited degree. For example, in U. S. Patent No. 2,200,034, a continuous process for digesting cellulosic material is described utilizing serially aligned horizontal tubular digesters. In operation, the charged cellulosic materials entering a first stage are substantially impregnated with chemical liquors at impregnation temperatures and pressures and are subsequently digested in later delignifying stages. As the delignifying reaction progresses, the cellulosic materials are passed to successive digesters by internal conveying screws mounted in each digester and thereafter are discharged from the last stage as digested pulp stock. The temperature and pressure in each digester is regulated by an individually associated recirculation and indirect heat exchange system. In U.S. Patent No. 2,474,862, a continuous process for digesting cellulosic materials is disclosed using a one stage vertical tubular digester which substantially parallels batch-operated processes, in that the charged cellulosic materials are substantially impregnated in the upper portion of the digester before attaining delignifying temperatures in the lower portion thereof. The pulp produced by this process appears to be equal to the pulp produced by batch-operated methods for similar cooking cycles.

It may be readily seen that both of the patented processes above, utilize new equipment and that the economics of constructing a plant at the expense of obsolescence of operable batch equipment becomes of paramount consideration. In order for the pulp and paper industry to accept and put into operation a continuous process for preparing pulp, economic necessity would dictate the utilization of available equipment of a prior installation unless a totally new installation is contemplated.

It is therefore a principal object of my invention to provide an improved continuously operated process for digesting cellulosic material in the preparation of pulp.

Another object of the invention is to provide an improved continuous process for digesting cellulosic material in which thorough impregnation of the material with delignifying chemicals is accomplished prior to actual digestion, thereby resulting in improved pulp products.

A further object of the invention is the provision of an improved process for the continuous digestion of cellulosic material adaptable to existing batch-wise operated equipment.

A still further object of the invention is to provide a continuous process for digesting cellulosic material which is easily and completely controlled with reduced labor and operating costs and which is economical with respect to steam consumption.

Other objects and a fuller understanding of my invention may be had by referring to the following description taken in conjunction with the accompanying drawing, in which the FIGURE is a flow diagram illustrating a preferred embodiment of my invention for effecting the continuous digestion of cellulosic materials in the preparation of pulp.

In accordance with my present invention, which is primarily applicable to the sulphate and soda processes and also to the long cook NSSC process, the above objects are accomplished by a novel utilization of two digesters or pressure cookers interconnected by a conduit communicating with the bottom of each digester. The cellulosic material to be digested is continuously charged to the upper zone of the first digester wherein the material, while descending to the bottom thereof, is substantially impregnated with chemical liquors. The impregnated material reaching the bottom of the first digester is continuously passed through the communicating conduit to the bottom of the second digester wherein the material, while ascending to the top thereof, is substantially digested at delignifying temperatures and pressures and thereafter discharged as a mixture of concentrated pulp stock and cooking liquor from the top of the second digester. In order to continuously charge raw material to and continuously remove delignified cellulosic material from the digesters, while operating at superatmospheric pressures and high temperatures, an admission valve and a blow valve are provided at the top of the first and second digester, respectively. Such valves operate to permit the transfer of material into and out of the high pressure digesters without an appreciable loss in the pressure medium therein. Further, a recirculation heat exchange system is provided to circulate the delignifying chemicals at controlled temperatures.

In operation, I propose to impregnate the charged cellulosic materials with chemical liquors in the first digester and raise the temperature therein to about 250° F. to 325° F. and thereafter raise the impregnated materials to delignifying reaction temperatures of from about 275° F. to 370° F. in the second digester. The digested stock leaving the second digester is discharged or blown into a blow tank wherein the stock is prepared for later processing operations.

I further propose to use an outage time equal to the combined time required for substantially heating up and cooking (at maximum cooking temperatures) a batch operated process having like digester volumes, thereby determining the rate of capacity of my continuous process. The effective capacity of my process, however, may increase by 50% the capacity of existing short cooking cycle plants such as produce high yield kraft pulp and may increase by about 20% the capacity of longer cooking cycle plants, since the time required for filling, blowing and related operations of batch systems are substantially eliminated.

Referring to the drawing, there is provided a digester tank, generally indicated at **1**, operating at superatmospheric pressures and at temperatures of from about 225° F. to 325° F. and functioning to receive and impregnate cellulosic materials prior to the actual digestion of such materials in a later stage. Digester **1** is comprised of a vertical tank including an annular wall **2**, base **3** and a top **4**, and associated apparatus as described hereinafter.

Within the digester tank **1**, intermediate of the base and top, there is mounted on the wall **2** a peripheral recirculation strainer **5** which forms with the wall **2** an annular recirculation liquor space **5*a*** communicating with a recirculation outlet **6**. Positioned above the intersection of wall **2** and base **3**, there is provided an annular distribution baffle **7**, fixed to such wall at its outer edge **7*a*** and extending in downward configuration to a point short of the base **3**, thereby forming an annular distribution space **7*b*** with wall **2**, which space communicates with the lower portion of digester **1** through annular orifice **7*c*** formed along edge **7*d*** of such baffle. Recirculation liquors enter the distribution space **7*b*** through the inlet **7*e*** and pass through orifice **7*c*** into the stock descending toward base **3** of the digester. Located on the exterior portion of the wall **2**, there is provided a header **8** communicating with a plurality of annularly spaced distribution pipes **9** evenly disposed and mounted therein and which extend through wall **2** upwardly into the digester at a point above the annular distribution baffle **7**. Heated recirculation liquors enter the header **8** through inlet **8*a*** and pass through pipes **9** into the digester for mixing therein with the descending stock.

In top **4** of digester **1** there is provided an inlet pipe **10** including a gas relief outlet **11**, which communicates via line **12** with a gas relief valve **13**. Integral with and extending beyond the inlet pipe **10**, there is provided an admission valve **14**, which may be constructed in accord with my U.S. Patent No. 2,732,086, and which functions to continuously admit charge stock to the high pressure impregnation zone without an appreciable loss of pressure within such zone. The admission valve **14** includes a bilateral valve **15** and a quadrant-sector valve **16** which are housed within outer casing **14*a***. The quadrant-sector valve **16** is mounted above the bilateral valve **15** and rotates through one-quarter revolution while the bilateral valve is motionless, whereas while the quadrant-sector valve **16** is motionless, the bilateral valve **15** rotates through one-half revolution.

The impregnated cellulosic material is primarily digested in a second digester, generally indicated at **17**, operating at superatmospheric pressures and at temperatures of from 275° F. to 370° F. Digester **17** is comprised of a vertical tank including an annular wall **18**, base **19** and top **20**, and associated apparatus as described hereinafter.

Within the digster **17**, intermediate of the base and top, there is mounted on the wall **18**, a peripheral recirculation strainer **21** which forms with the wall **18** an annular recirculation liquor space **21*a*** communicating with a recirculation outlet **22**. Axially located within the digester **17** near top **20** there is provided a directional baffle **23** mounted on supporting arms **23*a*** extending from the wall **18** and which forms therein with the wall **18** an annular space **23*b*** for the smooth passage of concentrated stock ascending to an outlet pipe **24**. Mounted on and integrally connected to pipe **24** is a blow valve **25** which may also be constructed in accord with my U.S. Patent No. 2,732,086. The blow valve **25** includes a quadrant-sector valve **26** and a bilateral valve **27** which are housed within outer casing **25*a***. Valve **25** operates in a manner similar to admission valve **14** in that the quadrant-sector valve **26** rotates through one-quarter revolution while the bilateral valve **27** is motionless, whereas while the quadrant-sector valve **26** is motionless, the bilateral valve **27** rotates through one-half revolution.

In order to continuously transfer to digester **17** the cellulosic materials impregnated in the digester **1**, there is provided a conduit **28** communicating with base **3** of digester **1** at one end and with the base **19** of digester **17** at the other end. The treated material descending to the bottom of digester **1** and passing into the conduit **28** is transferred to the bottom of digester **17** by high pressure steam entering the conduit **28** through a steam eductor **29** and the back pressure of recirculating liquors from digester **17** entering through orifice **7*c*** as described hereinafter.

In operation, the cellulosic materials are supplied from a chip source, such as a chip storage silo, generally indicated at **30**, and may be passed via chute **31** to conveyor **32** which is provided with a weightometer **33** and a tramp iron magnet **34**. The chips carried on conveyor **32** to a chip hopper **35** are continuously weighed by the weightometer **33**, which controls the quantity of chemical liquor later admitted to the system. The chips from the chip hopper **35** pass through quadrant-sector valve **16** and bilateral valve **15** of admission valve **14** to digester **1**, wherein the chips are impregnated with cooking liquor at superatmospheric pressures and at temperatures of from about 225° F. to 325° F. Admission valve **14** permits the cellulosic material to be continuously passed to the impregnation digester **1** without an appreciable loss in pressure therein and operates as follows; the quadrant-sector valve **16** and the bilateral valve **15** are intermittently operated, i.e. the quadrant-sector valve **16** rotates through one-quarter revolution while the bilateral valve is motionless, and the bilateral valve **15** rotates through one-half revolution while the quadrant-sector valve is motionless.

White cooking liquor and black buffering liquor at a temperature of from 160° F. to 180° F. from lines **36** and **37**, respectively, are passed via line **36*a*** into the upper portion of the bilateral valve **15**, wherein the liquors act as a snubber against steam leaking into the admission valve **14** from the digester **1**. The amount of white cooking liquor and black buffering liquor entering the system is controlled by the weight of the chips passing over the weightometer **33**. Black buffering liquor from line **37** is introduced with the white liquor so as to reduce the severity of the initial attack on the cellulosic material by the white cooking liquor. The chips entering the digester tank **1** through admission valve **14** fall to the top of the chips already in the tank (as indicated by the dotted lines) together with the white cooking liquor and black buffering liquor and are subsequently impregnated with such liquors and raised to a temperature of from about 225° F. to 325° F.

As indicated, digester **1** operates at superatmospheric pressures and high temperatures, which conditions are sustained by a recirculation heat exchange system. Recirculating liquors flowing within the digester move in a direction opposite to that of the chips and leave the digester **1** through the peripheral strainer **5** and pass through zone *5a* to recirculation liquor outlet **6**. The liquors from outlet **6** enters line **39** and are passed by pump **40** through line **41** to heat exchanger **42**. White cooking liquor and black buffering liquor may be admitted via line *38a* and *38b*, respectively, into line **39** to fortify the recirculation liquors therein. Steam from steam line **43** passes via line **44** into heat exchanger **42** for indirect heat exchange with the recirculation liquors and is thereafter discharged as condensate through line **45**. The quantity of steam entering heat exchanger **42** is regulated by a temperature responsive valve *44a* which is controlled by a temperature probe *44b* located within digester tank **1**. The recirculation liquors heated by the indirect heat exchange in exchanger **42** are sent via line **46** to header **8**, from which they are distributed by outlet pipes **9** into the lower portion of the digester **1**.

The chips descending in the digester are impregnated with the heated liquors, the countercurrent flow of which ensures for thorough impregnation. The impregnated stock descends to the portion of the digester **1** located below the baffle **7** and is passed through conduit **28** into the bottom of digester **17**. The passage of the impregnated stock to the digester **17** is induced by the back pressure of recirculating liquors from the digester **17** entering digester **1** from zone *7b* and passing through orifice *7c* into the descending impregnated stock, and by the steam eductor **29** positioned in the conduit **28** and supplied with steam from steam supply **43** via line **47**. The quantity of steam admitted into line **28** is regulated by a temperature responsive valve *47a* which is controlled by a temperature probe *47b* located within digester tank **17**.

Digester **17** operating at superatmospheric pressures and at temperatures of from about 275° F. to 375° F. cooks or digests the impregnated chips under delignifying conditions. The chemical liquor and impregnated chips in the digester **17** flow concurrently therein from bottom to top and are continuously discharged therefrom after a predetermined cooking cycle. The recirculation liquors admitted to digester **1** from distribution zone *7b* to induce the passage of the impregnated stock through conduit **28** are obtained from digester **17** by withdrawing through strainer **21** a portion of the chemical liquors, and which are thereafter passed from recirculation space *21a* through recirculation liquor outlet **22** into line **48**. The recirculation liquors in line **48** are passed by pump **49** through line **50** and enter digester **1** through recirculation inlet *7e* into the recirculation liquor zone *7b*, from which the liquors are distributed into the impregnated stock near the bottom of digester **17**.

The chips ascending to the top of digester **17** are substantially cooked, whereupon reaching the opening **24** are passed through blow valve **25** via line **51** into a blow tank **52** for further processing therein. Blow valve **25** comprised of quadrant-sector valve **26** and bilateral valve **27** operates to permit the passage of material from one pressure zone to another pressure zone without an appreciable loss of pressure therein. The operation of the blow valve **25** is similar to that of the admission valve **14**, in that the quadrant-sector **26** rotates through one-quarter revolution while the bilateral valve **27** is motionless and the bilateral valve **27** rotates through one-half revolution while the quadrant-sector valve **26** is motionless.

Since the digester **17** is operating at delignifying temperatures and pressures and the blow tank is at atmospheric pressure, the materials reaching the upper portion of bilateral valve **27** are substantially blown by flash steam through line **51** into the blow tank **52**.

The digested cellulosic materials entering blow tank **52** may be treated with dilution liquors from line **53** and **54**, the latter derived from the chemical liquor entering the lower portion of the bilateral valve **27** and withdrawn therefrom. The digested stock within the bottom of blow tank **52** is intimately blended and diluted by an impeller **55** to a pumpable consistency and is passed via line **56** and a pump **57** to later processing operations. The flash steam in the upper portion of the blow tank **52** rises to a flash condenser **58** associated therewith, and is condensed therein by a condensing fluid entering via line **59**. The resultant condensate is passed via line **60** to a heat recovery system (not shown).

While I have shown and described a preferred form of my invention, I am aware that variations may be made thereto and I, therefore, desire a broad interpretation of my invention within the scope of the disclosure herein and the following claims.

I claim:

1. A process for continuously treating cellulosic materials at superatmospheric pressure; which comprises introducing cellulosic material to be treated into the upper portion of a first digester and passing said material as a continuous downward flow therethrough, circulating chemical treating liquor through said digester in countercurrent flow to said downwardly flowing material whereby said liquor substantially impregnates said material, fortifying said circulating liquor with fresh chemical treating liquor, withdrawing said impregnated material and chemical treating liquor from said digester and passing said withdrawn material and liquor to a second digester for delignification of said impregnated material during passage therethrough, heating said withdrawn material and chemical treating liquor during said passage to said second digester to about the delignifying temperature employed for said delignification, and withdrawing substantially delignified cellulosic material from said second digester.

2. A process for continuously treating cellulosic materials at superatmospheric pressure; which comprises introducing cellulosic material to be treated into the upper portion of a first digester and passing said material as a continuous downward flow therethrough, passing chemical treating liquor through said digester in countercurrent flow to said downwardly flowing material whereby said liquor substantially impregnates said material, separating a portion of said treating liquor from said material, heating said separated liquor to the temperature employed for said impregnation, re-introducing said heated liquor into said digester, withdrawing said impregnated material and chemical treating liquor from said digester and passing said withdrawn material and liquor to a second digester for delignification of said impregnated material during passage upwardly therethrough, heating said withdrawn material and chemical treating liquor during said passage to said second digester to about the delignifying temperature employed for said delignification, and withdrawing substantially delignified cellulosic material from the upper portion of said second digester.

3. A process for continuously treating cellulosic materials at superatmospheric pressure; which comprises introducing cellulosic material to be treated into the upper portion of a first digester and passing said material as a continuous downward flow therethrough, passing chemical treating liquor through said digester in countercurrent flow to said downwardly flowing material whereby said liquor substantially impregnates said material, fortifying said circulating liquor with fresh chemical treating liquor, separating chemical treating liquor from said material at a point intermediate the top and bottom of said digester, heating said separated liquor to the temperature employed for said impregnation, re-introducing said heated liquor into said digester in countercurrent flow to said downwardly flowing material, withdrawing said impreg-

nated material and chemical treating liquor from said digester and passing said withdrawn material and liquor to a second digester for delignification of said impregnated material in said second digester, heating said withdrawn material and chemical treating liquor during said passage to said second digester to about the delignifying temperature employed for said delignification, passing said cellulosic material and chemical treating liquor through said second digester in concurrent upward flow whereby said chemical liquor substantially delignifies said material, and withdrawing substantially delignified cellulosic material from the upper portion of said second digester.

4. A process for continuously treating cellulosic materials at superatmospheric pressure; which comprises introducing cellulosic material to be treated into the upper portion of a first digester and passing said material as a continuous downward flow therethrough, passing chemical treating liquor through said digester in countercurrent flow to said downwardly flowing material whereby said liquor substantially impregnates said material, fortifying said circulating liquor with fresh chemical treating liquor, separating chemical treating liquor from said material at a point intermediate the top and bottom of said digester, heating said separated liquor to the impregnation temperature employed for said impregation, re-introducing said heated liquor into said digester in countercurrent flow to said downwardly flowing material, withdrawing said impregnated material and chemical treating liquor from said digester and passing said withdrawn material and liquor to a second digester for delignification of said impregnated material in said second digester, heating said withdrawn material and chemical treating liquor during said passage to the delignifying temperature employed for said delignification, passing said heated impregnated material and chemical treating liquor in concurrent upward flow through said second digester wherein said chemical treating liquor substantially delignifies said material, and withdrawing substantially delignified cellulosic material from the upper portion of said second digester.

5. A process for continuously treating cellulosic materials at superatmospheric pressure; which comprises introducing cellulosic material to be treated into the upper portion of a first digester and passing said material as a continuous downward flow therethrough, passing chemical treating liquor through said digester in countercurrent flow to said downwardly flowing material whereby said liquor substantially impregnates said material, fortifying said circulating liquor with fresh chemical treating liquor, separating chemical treating liquor from said material at a point intermediate the top and bottom of said digester, heating said separated liquor to the impregnation temperature employed for said impregnation, re-introducing said heated liquor into said digester in countercurrent flow to said downwardly flowing material at a point below the point of said separation, introducing additional chemical treating liquor into said digester in concurrent flow to said downwardly flowing material, withdrawing said impregnated material and chemical treating liquor from said digester and passing said withdrawn material and liquor to a second digester for delignification of said impregnated material during passage upwardly therethrough, heating said withdrawn material and chemical treating liquor during said passage to said second digester to about the delignifying temperature employed for said delignification, separating a portion of the chemical treating liquor from said material in said second digester at a point intermediate the top and bottom of said digester as said additional chemical treating liquor is introduced into said first digester, and withdrawing substantially delignified cellulosic material from the upper portion of said second digester.

6. A process for continuously treating cellulosic materials at superatmospheric pressure; which comprises introducing cellulosic material to be treated into the upper portion of a first digester and passing said material as a continuous downward flow therethrough; passing chemical treating liquor through said digester in countercurrent flow to said downwardly flowing material whereby said liquor substantially impregnates said material, the superatmospheric pressure within said digester being maintained substantially constant during said impregnation; fortifying said circulating liquor with fresh chemical treating liquor, separating chemical treating liquor from said material at a point intermediate the top and bottom of said digester; heating said separated liquor to the impregnation temperature employed for said impregnation; re-introducing said heated liquor into said digester in countercurrent flow to said downwardly flowing material at a point below the point of said separation; introducing additional chemical treating liquor into said digester in concurrent flow to said downwardly flowing material; withdrawing said impregnated material and chemical treating liquor from said digester and passing said withdrawn material and liquor to a second digester for delignification of said impregnated material in said second digester, the superatmospheric pressure within said digester being maintained substantially constant during said delignification; heating said withdrawn material and chemical treating liquor during said passage to the delignifying temperature employed for said delignification; passing said heated impregnated material and chemical treating liquor in concurrent upward flow through said second digester wherein said chemical treating liquor substantially delignifies said impregnated material; separating chemical treating liquor from said material in said second digester at a point intermediate the top and bottom thereof, said separated chemical treating liquor comprising the additional chemical treating liquor admitted in concurrent flow to said material in said first digester; and withdrawing substantially delignifying cellulosic material from the upper portion of said second digester at the top thereof.

7. In a process as claimed in claim 6 wherein the heating of the continuously withdrawn material and chemical treating liquor to the delignifying temperature is accomplished by introducing steam thereto during said passage.

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