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## (54) Impregnation with black liquor prior to white liquor introduction.

(57) A method of continuously digesting comminuted cellulosic fibrous material (e.g. wood chips) is provided which simultaneously improves uniformity of the end product and has substantial energy economy. The chips are slurried, e.g. with black liquor, and fed to the top of a vertical digester. In the digester the chips are soaked in and heated with black liquor withdrawn from near the bottom of the cooking zone, which black liquor is at cooking temperature. White liquor (kraft cooking liquor) introduced into the cooking zone is preheated by passing it in heat exchange relationship with a portion of the black liquor withdrawn from the digester, so that only a small amount of heat in the form of steam need be added to the white liquor to bring it to cooking temperature. At the top of the digester, a portion of the liquid in the slurry can be withdrawn through a screen, pressurized, and then introduced under pressure with a downward velocity component facilitating a zone of concurrent movement of the chips and liquor.

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## BACKGROUND AND SUMMARY OF THE INVENTION

For several decades, continuous cooking of comminuted cellulosic fibrous material (e.g. wood chips) to produce pulp, particularly kraft pulp, has been an extremely efficient system for producing the pulp. Whenever continuous cooking is practiced, however, care must be taken to ensure uniformity of the end product. An important part of ensuring uniform quality of the end product is ensuring proper impregnation of the material with cooking liquor (white liquor). It has long been known that freshly cut wood, with high moisture content, will impregnate quickly and uniformly, whereas stored wood, with low moisture and high air content, requires efficient presteaming and favorable impregnation conditions in order to be uniformly impregnated. Despite the fact that this has been known for many years, this fact has not normally been effectively utilized to ensure uniform impregnation of cellulosic material, such as wood chips.

As energy conservation becomes more important, it also becomes important to minimize energy use during cooking. Typically, a substantial amount of energy in the form of high pressure steam is consumed in a continuous pulping facility by heating the white liquor to an appropriate cooking temperature (e.g. approximately 160-180°C).

According to the present invention, a method of continuously treating comminuted cellulosic fibrous material to produce paper pulp, particularly kraft pulp, is provided which has enhanced uniformity and minimized energy requirements. According to the present invention, impregnation by rapid diffusion is accomplished so that the uniformity of treatment is enhanced, and preferably the cooking liquor is passed in heat exchange relationship with black liquor withdrawn from a digester so as to preheat the cooking liquor. This minimizes the consumption of high pressure steam in a conventional indirect heater.

According to one aspect of the present invention, a method of effecting continuous kraft cooking of comminuted cellulosic fibrous material is provided. The method comprises the steps of continuously: (a) Effecting rapid displacement heating of comminuted cellulosic fibrous material moving in a first flow path by introducing black liquor, substantially at cooking temperature, into the material moving in the first flow path. Then (b) effecting rapid diffusion impregnation of the material moving in a second flow path, after the first flow path, by introducing white liquor into the material moving in the second flow path. And then (c) effecting continuous kraft cooking of the material. Step (b) is preferably practiced by introducing the white liquor substantially at cooking temperature into the second flow path, after it has been passed into heat exchange relationship with the black liquor substantially at cooking temperature.

According to another aspect of the present invention, a method of continuously treating comminuted cellulosic fibrous material to produce kraft pulp comprises the steps of continuously: (a) Slurrying comminuted cellulosic fibrous material with liquid to produce a slurry. (b) Feeding the slurry into a soaking and heating zone. (c) Heating and soaking the slurry with heating and soaking liquid in the heating and soaking zone. (d) Feeding the slurry from the heating and soaking zone into an impregnation and cooking zone. (e) Treating the slurry with kraft cooking liquor at cooking temperature in the impregnation and cooking zone to effect digestion of the material in the slurry, to produce kraft pulp. (f) Withdrawing black liquor from the impregnation and cooking zone, at cooking temperature. And, (g) feeding at least a portion of the black liquor withdrawn in step (f) to the soaking and heating zone to provide at least a part of the soaking and heating liquid in step (c). There is preferably also the further step (h) of preheating the cooking liquor before feeding it into the impregnation and cooking zone by passing it into heat exchange relationship with a first portion of the black liquor withdrawn in step (f), while a second portion of the black liquor withdrawn in step (f) is used in step (g).

Step (b) may be practiced in part by withdrawing a portion of the liquid from the slurry at a withdrawal area above the heating and soaking zone, pressurizing the withdrawn liquid, and introducing the pressurized withdrawn liquid into the slurry, above the withdrawal area, with a primarily downward vector. Steps (c) and (g) are preferably practiced by withdrawing a portion of the liquid from the slurry in the heating and soaking zone at a withdrawal area, recirculating the withdrawn liquid back into the heating and soaking zone above the withdrawal area, and adding black liquor from step (f) to the recirculating withdrawn liquid. Step (a) is preferably practiced by slurrying the material with black liquor. Steps (b)-(f) are preferably practiced in a single vertical vessel, the material moving downwardly in the vessel during treatment.

According to a still further aspect of the present invention, a method of treating a slurry of comminuted cellulosic fibrous material in an upright vessel having a top and bottom, and at least first, second, and third sets of screens, vertically spaced from each other with the first set of screens the topmost screens, and the third set the bottom most, is provided. This method comprises the steps of: (a) Introducing the slurry into the top of the vessel, to flow downwardly therein. (b) Withdrawing a part of the liquid from the slurry with the first set of screens, and recirculating the withdrawn liquid back into the vessel above the first set of screens. (c) Withdrawing a part of the liquid from the slurry with the second set of screens, and recirculating the withdrawn liquid back into the vessel above the second set of screens. (d) Withdrawing a part of the liquid from the slurry with the third set of screens, and

passing at least a portion of the withdrawn liquid from the third set of screens into the withdrawn liquid from the first set of screens, to be introduced into the vessel with the recirculated liquid from step (b). And, (e) discharging pulp from the bottom of the vessel, below the third set of screens. A fourth set of screens is also preferably utilized, above the first set. Liquid is withdrawn through the fourth set of screens, pressurized, and then introduced above the fourth set of screens with a substantially downward velocity vector so as to assist in movement of the material.

It is the primary object of the present invention to provide for the continuous cooking of pulp with substantial energy economy and simultaneously improved uniformity of the end product. This and other objects of the invention will become clear from an inspection of the detailed description of the invention, and from the appended claims.

## BRIEF DESCRIPTION OF THE DRAWING

FIGURE 1 is a schematic view of an exemplary apparatus for practice of the method according to the present invention.

## DETAILED DESCRIPTION OF THE DRAWING

Many of the components of the apparatus illustrated in FIGURE 1 are the same as, or comparable to, parts of the apparatus of U.S. patent 3,802,956, the disclosure of which is hereby incorporated by reference herein. That patent shows apparatus for effecting continuous pulping, particularly kraft pulping, of comminuted cellulosic fibrous material, with a view toward proper impregnation of the material.

Apparatus of the system of FIGURE 1 that is generally comparable to that in said patent 3,802,956 includes a chips bin 11 (which may be a steaming chips bin), communicating with a low pressure valve 13 with a conventional steaming vessel 14. Low pressure steam, e.g. one atmosphere over pressure, is supplied to the vessel 14 through a conduit 15, and air is driven off through conduit 17. The chips ultimately pass through chute 18 into the conventional high pressure feeder 19, circulating liquid being forced by pump 20 to entrain chips -- or like cellulosic fibrous material -- dropping from chute 18 into the transfer device 19 in the circulating liquid.

According to the invention, the chips from high pressure feeder 19 pass in conduit 21 to the top of a substantially vertical digester 22. The slurry of chips in liquid passes into apparatus at the top of the digester 22 for separating a portion of the liquid, the apparatus preferably comprising a strainer girdle 25 with a feed screw 27 therein, and the withdrawn liquid passing in conduit 23 back to the pump 20. A screen 28 is provided adjacent to the top of the digester 22, but below the girdle 25 and screw 27, connected to pump 26, which in turn is connected to nozzles 24. A portion of the liquid withdrawn from the slurry through screen 28 is pressurized by pump 26 and then forced through the nozzles 24 back into the vessel, above the screen 28, with a substantially downward velocity vector. This system is primarily for producing a downward thrust on the material for operational purposes, so that it flows concurrently with liquid initially down into the digester 22. A portion of the liquid withdrawn by screen 28 is passed via conduit 30 to the second effect 90 of a flash tank system, as hereinafter described.

The chips are flushed into the high pressure feeder 19 through chute 18 via liquid flowing in loop 37 under the influence of pump 35. Excess liquid passes into level tank 39 and is returned therefrom through conduit 41 and pump 29 to the high pressure side. Additionally, make-up liquor -- which may be black liquor from source 33, white liquor from source 31, or a combination of both (as metered by valve 48), and valves 10, 12, may be provided. This liquid passes to the top exterior of the strainer girdle 25 -- i.e. the high pressure loop -- via conduit 50.

Below the screen 28 adjacent the top of the vessel 22 is a soaking and heating zone. A screen 40, connected to a pump 42, is provided in the soaking and heating zone. The pump 42 withdraws a portion of the liquid from the slurry moving downwardly in the vessel 22, and recirculates it in loop 43 to the inlet tube 46 above the screen 40. Liquid introduced thereby tends to flow countercurrently to the chips moving downwardly in the vessel 22, ultimately being withdrawn by screen 28. A heater, such as an indirect heater (heating liquid with steam), may be provided in the circulation loop 43, but is not necessary according to the invention.

Below the screen 40, an impregnation and cooking zone is provided. Within the impregnation and cooking zone are one or more screens 63, 87, and 92. A portion of the liquid in the slurry moving downwardly at the screen 63 is withdrawn therefrom via pump 65, and passed through conventional indirect steam heater (heat exchanger) 67 to be heated, the withdrawn liquid being recirculated and introduced at central return conduit 69 into the chips column above the screen 63. According to the present invention, kraft cooking liquor (white liquor) from source 31 may be pumped by pump 36 to this recirculation loop, e.g. added to the pump 65 to be introduced with the recirculated liquid.

The screens 87 and 92 withdraw black liquor from the digester 22. A portion of the black liquor withdrawn by screen 92 under the influence of pump 93 may be recirculated into the digester 22 and introduced at central conduit 95, while another portion passes through valve 32 ultimately to the second stage flash tank 90. The conduit 91 from the bottom of the flash tank 90 may be used to supply black liquor to the

source 33. Also, according to the present invention, black liquor withdrawn through screen 87 passes into conduit 110, which is connected to the circulation loop 43 including the pump 42, so that it is introduced at the return conduit 46 into the vessel. The black liquor in conduit 110 is substantially at cooking temperature (e.g. about 160-180°C).

Another portion of the liquor withdrawn with screens 87 -- which also is at substantially cooking temperature -- is used to preheat white liquor introduced from source 31 into pump 65. This may preferably be accomplished by passing the conduit 112 and the conduit 38 into a heat exchanger 114, whereby the black hot liquor in conduit 112 comes into heat exchange relationship with the cool white liquor in conduit 38, preheating it before it is introduced into pump 65. Typically, the heat exchanger 114 would preheat the white liquor from about 70°C to about 160°C. Little additional energy input is required from the heater 67. After losing a substantial portion of its heat value in heat exchanger 114, the remaining black liquor in conduit 112 is passed to a first stage flash tank 89.

The arrangement described above, in addition to obviously minimizing energy requirements, also effects very uniform impregnation. The black liquor introduced from conduit 110 soaks and heats the chips, effecting rapid displacement heating thereof. This rapid displacement heating makes the chips much more amenable to impregnation with white liquor. That means when the chips pass downwardly into the impregnation and cooking zone, and are confronted with hot white liquor, rapid diffusion impregnation of the chips with white liquor occurs. The chips are then cooked at a temperature of about 160-180°C, and then passed downwardly into the lower part of the digester 22 where they are preferably washed.

Near the bottom of the vessel 22 a screen 79 is connected to a pump 81, heater 83, and central supply conduit 85. Washing liquid is introduced into the conduit 71 to flow countercurrently (that is upwardly) with respect to the downward flowing chips, with a portion of the liquid being withdrawn through screen 79, heated, and recirculated back into conduit 85. The washed, kraft pulp, may then be discharged from the bottom of the vessel utilizing a conventional rotary scraper 99, and a throttling device 101 if desired.

While the method has been described with respect to a single upright vessel 22, the method may be practiced otherwise (e.g. with more than one vessel), although the single vessel arrangement of FIGURE 1 is greatly preferred.

According to one aspect of the method of the present invention, a slurry of comminuted cellulosic fibrous material (e.g. wood chips) in liquid (e.g.. black liquor combined with steam which condensed on the chips from steaming vessel 14, and any natural liquid in the chips) is fed to the top of the digester 22, and under the influence of the downwardly directed flow of liquid from nozzles 24 moves downwardly in the vessel 22. At a first set of screens 40 part of the liquid in the slurry may be removed, and introduced back into the vessel, with black liquor withdrawn through screen 87 by conduit 110 being introduced into the recirculation loop 43. Thus in the vicinity of the screen 40, and above, the chips are soaked and heated, the black liquor in conduit 110 being substantially at cooking temperature. This rapid displacement heating of the chips makes them susceptible to subsequent impregnation during the continuous processing thereof.

As the chips move downwardly further in the vessel 22 they encounter the second set of screens 63. A portion of the liquid is withdrawn therethrough, heated by heater 67, and reintroduced by central conduit 69. White liquor from source 31, pumped by pump 36, in conduit 38 is added to the pump 65 in this recirculation loop. Preferably the white liquor is preheated by passing it through the heat exchanger 114, in heat exchange relationship with black liquor in conduit 112. Since the chips are susceptible to impregnation due to their soaking and heating by rapid displacement heating, rapid diffusion impregnation of the chips with white liquor occurs adjacent the screen 63 and thereabove. Below the screen 63, kraft cooking of the chips takes place. The chips are ultimately washed at or above screen 79, and are subsequently discharged from the bottom of the vessel.

It will thus be seen that according to the present invention a method of effecting substantial energy economy while simultaneously improving uniformity of the pulp produced in a continuous kraft pulping process, is provided. While the invention has been herein shown and described in what is presently conceived to be the most practical and preferred embodiment thereof, it will be apparent to those of ordinary skill in the art that many modifications may be made thereof within the scope of the invention, which scope is to be accorded the broadest interpretation of the appended claims so as to encompass all equivalent methods and procedures.

## Claims

1. A method of continuously treating comminuted cellulosic fibrous material to produce kraft pulp, comprising the steps of continuously:

   (a) slurrying comminuted cellulosic fibrous material with liquid to produce a slurry;

   (b) feeding the slurry into a soaking and heating zone;

   (c) heating and soaking the slurry with heating and soaking liquid in the heating and soaking zone;

   (d) feeding the slurry from the heating and

soaking zone into an impregnation and cooking zone;
(e) treating the slurry with kraft cooking liquor at cooking temperature in the impregnation and cooking zone to effect digestion of the material in the slurry, to produce kraft pulp;
(f) withdrawing black liquor from the impregnation and cooking zone, at cooking temperature; and
(g) feeding at least a portion of the black liquor withdrawn in step (f) to the soaking and heating zone to provide at least a part of the soaking and heating liquid in step (c).

**2.** A method as recited in claim 1 wherein steps (f) and (g) are practiced so that all of the soaking and heating liquid supplied to the soaking and heating zone is black liquor from step (f).

**3.** A method as recited in claim 2 wherein step (e) is practiced by feeding kraft cooking liquor from outside the impregnation and cooking zone into the impregnation and cooking zone, and comprising the further step of (h) preheating the cooking liquor before feeding it into the impregnation and cooking zone by passing it in heat exchange relationship with a first portion of the black liquor withdrawn in step (f), while a second portion of the black liquor withdrawn in step (f) is used in step (g).

**4.** A method as recited in claim 3 comprising the further step of further heating the cooking liquor, after preheating thereof in step (h), by passing it into indirect heating relationship with steam.

**5.** A method as recited in claim 3 comprising the further step of (i) introducing the first portion of black liquor, after practice of step (h), into a flash tank.

**6.** A method as recited in claim 1 wherein step (b) is practiced by withdrawing a portion of the liquid from the slurry at a withdrawal area above the heating and soaking zone, pressurizing the withdrawn liquid and introducing the pressurized withdrawn liquid back into the slurry, above the withdrawal area, with a primarily downward vector.

**7.** A method as recited in claim 1 wherein steps (c) and (g) are practiced by withdrawing a portion of the liquid from the slurry in the heating and soaking zone at a withdrawal area, recirculating the withdrawn liquid back into the heating and soaking zone above the withdrawal area, and adding black liquor from step (f) to the recirculating withdrawn liquid.

**8.** A method as recited in claim 1 wherein step (e) is further practiced by withdrawing liquid from the impregnation and cooking zone at a withdrawal area, recirculating the withdrawn liquid back to the impregnation and cooking zone at a point above the withdrawal area, and adding the kraft cooking liquor to the recirculating withdrawn liquid.

**9.** A method as recited in claim 8 wherein steps (c) and (g) are practiced by withdrawing a portion of the liquid from the slurry in the heating and soaking zone at a withdrawal area, recirculating the withdrawn liquid back into the heating and soaking zone above the withdrawal area, and adding black liquor from step (f) to the recirculating withdrawn liquid.

**10.** A method as recited in claim 9 wherein step (b) is practiced by withdrawing a portion of the liquid from the slurry at a withdrawal area above the heating and soaking zone, pressurizing the withdrawn liquid, and introducing the pressurized withdrawn liquid back into the slurry, above the withdrawal area, with a primarily downward vector.

**11.** A method as recited in claim 10 wherein steps (b)-(f) are practiced in a single vertical vessel, and wherien steps (b) and (d) are practiced by feeding the slurry downwardly.

**12.** A method as recited in claim 1 wherein step (e) is practiced by feeding kraft cooking liquor from outside the impregnation and cooking zone into the impregnation and cooking zone, and comprising the further step of (h) preheating the cooking liquor before feeding it into the impregnation and cooking zone by passing it in heat exchange relationship with a first portion of the black liquor withdrawn in step (f), while a second portion of the black liquor withdrawn in step (f) is used in step (g).

**13.** A method as recited in claim 12 comprising the further step of further heating the cooking liquor, after preheating thereof in step (h), by passing it into indirect heating relationship with steam.

**14.** A method as recited in claim 12 comprising the further step of (i) introducing the first portion of black liquor, after practice of step (h), into a flash tank.

**15.** A method as recited in claim 1 wherein step (a) is practiced utilizing black liquor as the slurrying liquid.

16. A method of effecting continuous kraft cooking of comminuted cellulosic fibrous material, comprising the steps of continuously:

(a) effecting rapid displacement heating of comminuted cellulosic fibrous material moving in a first flow path by introducing black liquor, substantially at cooking temperature, into the material moving in the first flow path; then

(b) effecting rapid diffusion impregnation of the material moving in a second flow path, after the first flow path, by introducing white liquor into the material moving in the second flow path; and then

(c) effecting continuous kraft cooking of the material.

17. A method as recited in claim 16 wherein step (b) is practiced by introducing the white liquor substantially at cooking temperature into the second flow path.

18. A method as recited in claim 17 wherein step (b) is further practiced by passing the cooking liquor into heat exchange relationship with black liquor substantially at cooking temperature before introducing the cooking liquor into the material.

19. A method as recited in claim 16 wherein the first and second flow paths are both downward, and in the same vessel, the second flow path merely being a continuation of the first.

20. A method of treating a slurry of comminuted cellulosic fibrous material in an upright vessel having a top and a bottom, and at least first, second and third sets of screens, vertically spaced from each other with the first set of screens the topmost screens, and the third set the bottommost, comprising the steps of:

(a) introducing the slurry into the top of the vessel, to flow downwardly therein;

(b) withdrawing a part of the liquid from the slurry with the first set of screens, and recirculating the withdrawn liquid back into the vessel above the first set of screens;

(c) withdrawing a part of the liquid from the slurry with the second set of screens, and recirculating the withdrawn liquid back into the vessel above the second set of screens;

(d) withdrawing a part of the liquid from the slurry with the third set of screens, and passing at least a portion of the withdrawn liquid from the third set of screens into the withdrawn liquid from the first set of screens, to be introduced into the vessel with the recirculated liquid from step (b); and

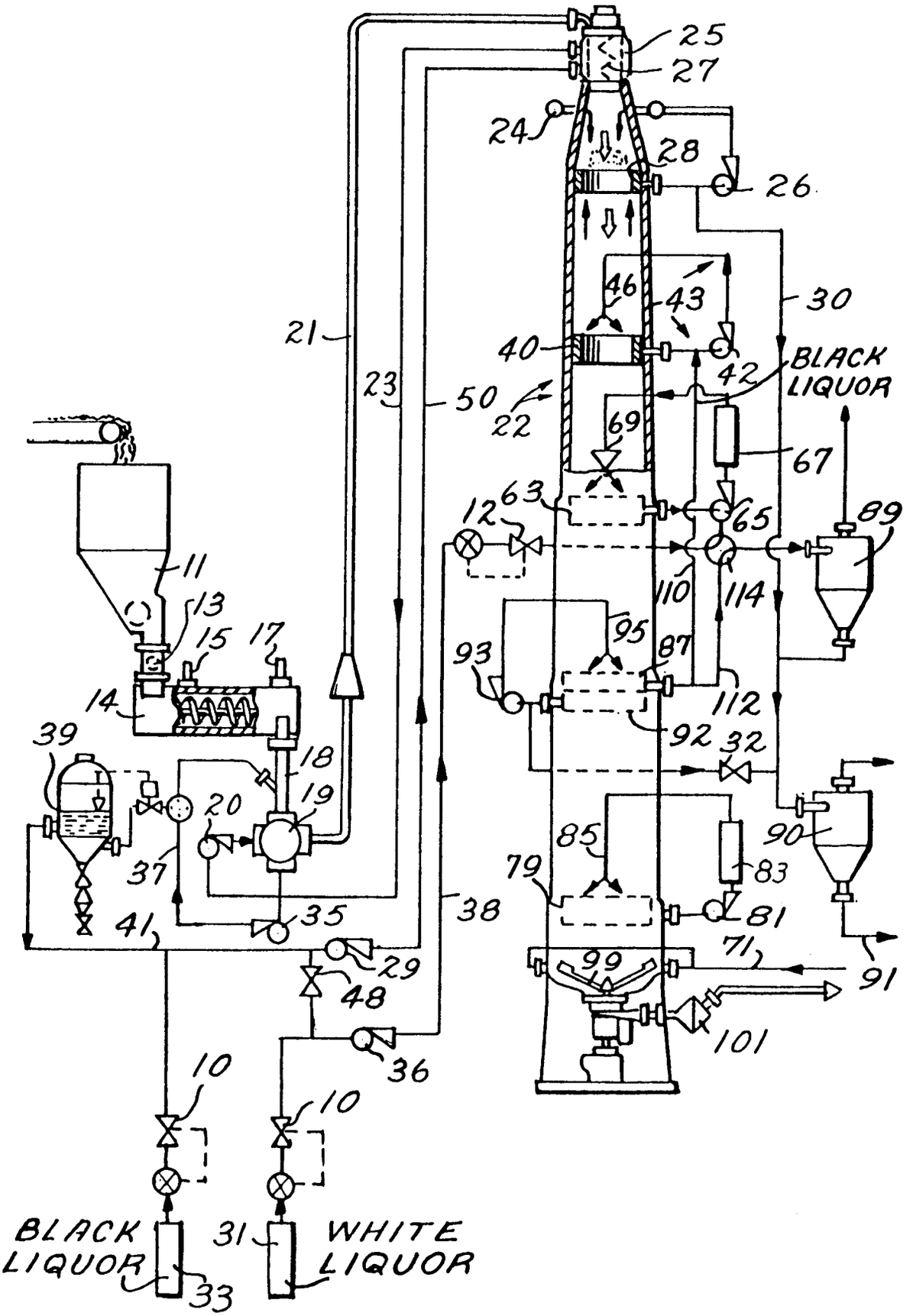
(e) discharging pulp from the bottom of the vessel, below the third set of screens.

21. A method as recited in claim 20 comprising the further step of (f) introducing additional liquor, from an outside source, into the liquid being recirculated in step (c).

22. A method as recited in claim 21 wherein step (f) is practiced by passing the additional liquor into heat exchange relationship with a first portion of the liquid withdrawn in step (d), prior to introducing it into the recirculated liquid, and wherein a second portion of the liquid withdrawn in step (d) is introduced into the recirculated liquid in step (b).

23. A method as recited in claim 20 wherein the vessel has a fourth set of screens located above the first set of screens, and comprising the further step of (g) withdrawing a portion of the liquid in the slurry with the fourth screens, pressurizing the withdrawn liquid and introduce the pressurized withdrawn liquid back into the slurry, above the fourth screens, with a primarily downward vector.

24. A method as recited in claim 20 wherein the slurry of comminuted cellulosic fibrous material comprises wood chips entrained in black liquor.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