

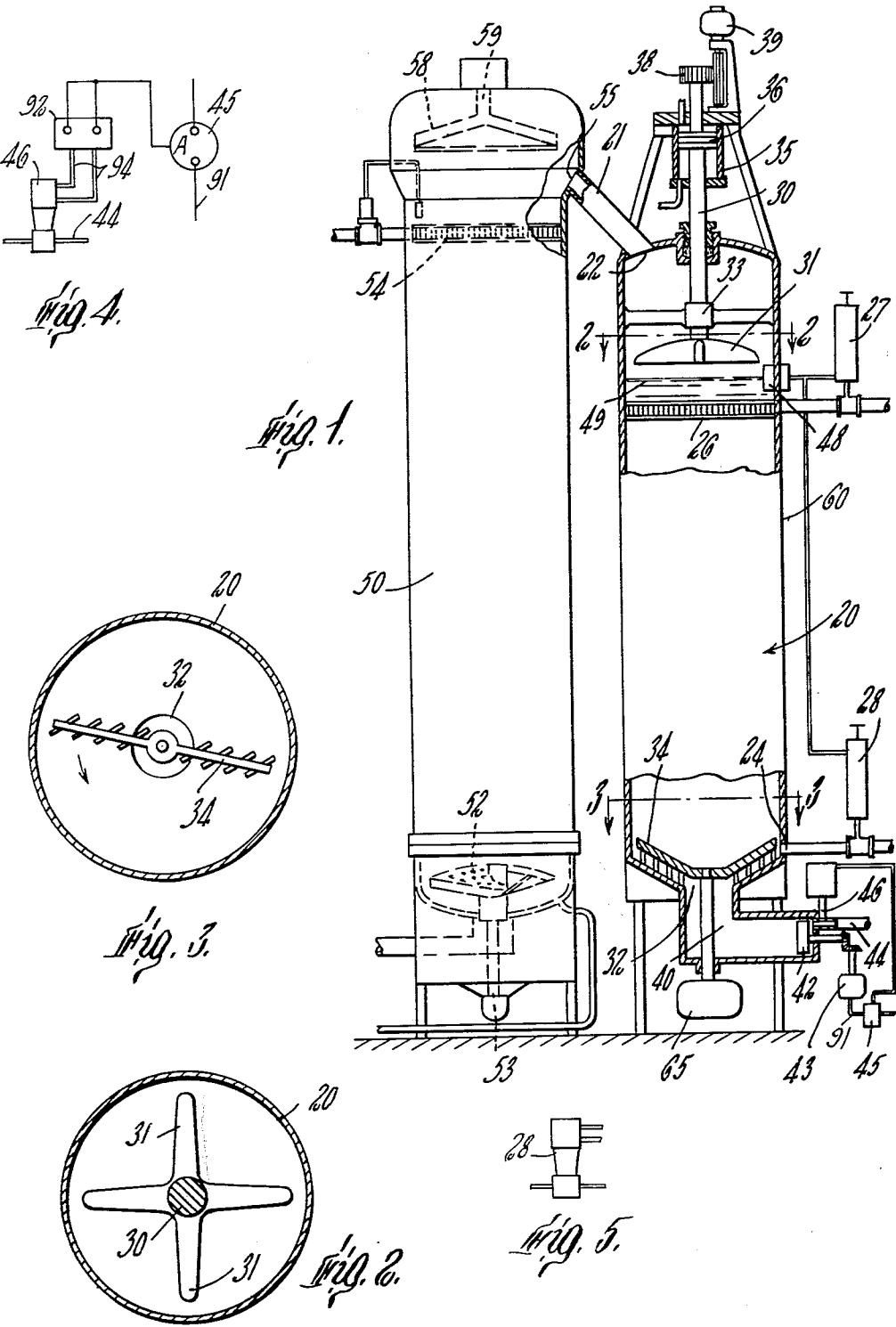
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DOWNFLOW COUNTERCURRENT WASHING APPARATUS

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DOWNFLOW COUNTERCURRENT WASHING APPARATUS

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This invention relates to continuous pulping apparatus and systems. More particularly, it relates to novel downflow washing apparatus for advancing solid particles downwardly through a vessel containing a solid particle-liquid mixture, movement of the solid particles being controlled independently of the liquid, as well as to novel systems wherein such apparatus is combined with a continuous upflow digester of the type shown in Patent No. 2,878,116. It is a continuation-in-part of my application Serial No. 29,756, filed May 17, 1960, and now abandoned.

More specifically, in that patent is shown and described a novel continuous digester for the production of wood pulp, such digester having wood chip lifting means at its bottom for advancing wood chips as a compacted mass throughout the effective length of the reaction vessel. This apparatus has proved to be highly efficient in providing a stable reaction environment for the continuous pulping of wood chips, even in large vessels of about ten feet in diameter and a hundred feet in length. The upflow arrangement therein shown is essential for conducting continuously processes such as wood chip digestion, in which the temperature of the process increases from the beginning toward the end, because it places the liquid of highest temperature at the top of the apparatus so that thermal convection will stabilize rather than upset the desired temperature distribution. This is vital in large reaction vessels operating at elevated temperatures. Furthermore, because of the direct control of chip movement made possible by the novel wood chip lifting means of said Patent No. 2,878,116, it is entirely possible to provide for countercurrent liquid flow as may be desirable.

For certain continuous processes, however, especially those associated with the operation of an upflow digester as above described, it is desirable to provide for washing of the digested chips after their reaction is completed. However, if the requisite temperature stability is to be established and maintained, i.e., with the higher temperature environment at the top of the washing vessel, downflow apparatus must be utilized. Furthermore, accurate control of movement of wood chips through such apparatus must be accomplished, so that the digested wood chips during the washing and cooling process can be moved from the top to the bottom of the washing and cooling vessel at a predetermined rate. As a practical matter, it has been considered difficult to achieve the desired results, especially in a continuously operating system.

According to the present invention, a countercurrent diffusion downflow washer for digested wood chips or the like is provided. In this process, cold wash liquid is introduced at the pulp discharge end of the washing and cooling vessel such liquid being thereafter heated to a higher temperature by its countercurrent upward passage through the downwardly moving mass of cooked chips, the chips in like fashion being cooled by the countercurrent flow of liquid. For temperature stability in such a system, that is, with the higher temperatures at the top and the lower temperatures at the bottom, downflow chip movement is required; yet such chip movement must be accurately controlled for uniform treatment in continuous system. This is made difficult because countercurrent, that is, upward flow of liquid is also required, which liquid flow tends to overcome any tendency of the chips to move

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downwardly in a uniform manner throughout the length of the vessel.

Apparatus has been provided in accordance with the principle of the invention which is capable of advancing digested wood chips downwardly through a vertical elongated washing and cooling vessel in a direction countercurrent to the direction of liquid flow therein. This has been accomplished by providing solid-particle downfeeding means at the upper end of the vessel, which means exerts force only on wood chips or other particles located adjacent upper end of the vessel progressively to advance a mass of wood chips filling the vessel below such downfeeding means downwardly throughout the length of the vessel. The intermediate portion of the vessel is thus entirely unobstructed for wood chip advance and for upward flow of a washing and cooling liquid as desired, the liquid being introduced into the vessel adjacent the lower end thereof and being moved upwardly as its temperature increases due to heat exchange with the downwardly moving chips.

In addition to being useful for conducting processes in which countercurrent washing and cooling liquid flow must be utilized particularly in conjunction with downwardly moving chips in which the temperature must decrease as the washing proceeds, the downflow washing apparatus of the invention is particularly adapted for use in conjunction with an upflow wood chip digester, since by so doing the cooked chips can be discharged directly from the top of the digester into the top of the downflow washing vessel, so that it can be pressurized for use in conjunction with a pressurized digester so that the connection for wood chip movement between these two vessels need only be an open pipe.

Thus, the invention may provide a system comprised of two vessels, for example, for countercurrent washing and cooling of wood chips in conjunction with a continuous digester. This is possible because of the novel apparatus provided, as well as the continuous digester, such as that shown in Patent No. 2,878,116, is of the continuously operating type capable of precise adjustment as to feed rates and treatment of the solid particles therethrough, for synchronization of each element of this system so that the system may operate as a single unit. This makes possible the uniform treatment on a continuous basis of wood chips in the production of pulp for the manufacture of paper, for example, and such treatment is, by means of the apparatus of the invention, continuously controllable for the precise kind and degree of treatment desired.

For the purpose of explaining further objects and features of the invention, reference is now made to the following detailed description of a preferred embodiment of the invention, taken with the accompanying drawings, wherein:

FIG. 1 is a diagrammatic side elevation of a continuous pulping system according to the invention employing a downflow washing and cooling vessel of the invention in conjunction with a pressurized upflow reaction vessel;

FIG. 2 is a cross sectional plan view showing the downfeeding means of FIG. 1, taken on the line 2—2 thereof;

FIG. 3 is a cross sectional plan view showing the discharge means of the washing and cooling vessel of FIG. 1;

FIG. 4 is a schematic view of an automatic control system adapted to be combined with the system of FIG. 1 to effect automatic operation thereof, and

FIG. 5 shows a modification of FIG. 4.

In FIGS. 1—3 is shown a complete continuous pulping system including an upflow reaction vessel and a downflow washing and cooling vessel directly connected thereto. In general, in such system, wood chips are fed into the reaction vessel; the chip lifter means of the reaction vessel moves the wood chips upwardly therethrough, while

the wood chips are being treated by suitable chemical reagents at high temperatures and pressures and thereafter the so treated wood chips are discharged directly into the downflow washing and cooling vessel. The treated wood chips are moved downwardly through the washing and cooling vessel, during which time they are washed by a countercurrent flow of a suitable washing liquid which also serves to lower the temperature of the chip mass as it advances. The treated washed chips are then discharged to atmospheric pressure, breaking them up into individual fibers as is desired.

Turning now to the specific chip washing and cooling vessel 20 of FIG. 1, the vessel 20 itself is of generally cylindrical form but preferably slightly tapered to expand in a downward direction, say, of the order of $\frac{1}{4}$ to $\frac{1}{2}$ inch per foot of length. In the upper end of the vessel is mounted the downfeeding means as is hereinafter described. Thereabove is a chip inlet opening 22 through which chips may be fed into the vessel 20 above the downfeeding means. At the bottom of the tower is a discharger means hereinafter more fully described enabling the feeding of the washed and cooled chips from the lower end of the chip mass to atmospheric pressure, and, if desired, in a desirable disintegrated condition for feeding to subsequent stages of the paper making process, for example. The downfeeding means utilized in vessel 20 to insure the downward advance of chips as a compacted mass, comprises a web-like member mounted adjacent the upper end of the vessel for generally vertical reciprocatory movement having a stroke of, say, about 3 to 24 inches. Preferably, said member includes a vertically arranged central shaft 30 having a plurality of spoke-like operating elements 31, herein shown as four in number, mounted on the lower end of shaft 30 and extending radially thereof with uniform angular spacing. These operating elements 31 provide an interrupted operating surface extending in a horizontal plane for free passage of the wood chips or other solid particles therethrough. The operating elements thus provide a downfeeding and tamping means extending generally throughout the horizontal area of the vessel with a working area of about 10 to 80 percent of the total area, preferably about 20%.

The shaft 30 is mounted in a suitable bearing 32 near its lower end above elements 31 and at its upper end it carries a piston 36 which operates in a double acting cylinder 35 having suitable fluid inlet means to each chamber thereof as well as means for supplying fluid to said inlets in a manner to reciprocate the piston at the rate of a few strokes per minute, say, 1 to 30, and preferably about 5.

Shaft 30 is also provided with a gear 38 operated by a suitable fluid motor 39, so that the elements 31 may be rotated bodily with shaft 30 as desired. Such rotation may desirably be accomplished on the up stroke and may be through a small increment, say, about 10 degrees, so that the elements 31 come down at a different place on the chip pile on each reciprocation.

When chips as a solid-particle liquid mixture are fed into the vessel above the elements 31 they will tend to flow past and under the elements 31 as the elements lift and then are tamped and fed downwardly by the elements as the elements subsequently complete their downward stroke. The reciprocating tamping action of elements 31 compacts the wood chips or other solid particles as they are fed into the vessel and advances them as a compacted mass downwardly through the vessel. This permits the uniform advance of the wood chips through an unobstructed tower for fluid treatment irrespective of the effect of the fluid on the buoyancy of the chips, for example. Thus, if a liquid be employed in which the chips are normally buoyant, the downfeeding means of the invention makes possible the downward advance of the chips, even with countercurrent liquid flow or the generation of steam which would also tend to oppose their advance. Furthermore, the uniformly compacted mass of chips extending throughout the effective length of the vessel, as is made

possible by the positive downfeed characteristic of the invention, greatly aids in making possible uniform chip treatment, by preventing non-uniform channeling and blockage. This is particularly vital in large diameter vessels.

At the bottom of vessel 20, a central discharge passage 32 is provided, as well as a scraper 34 driven by a motor 65 for moving the treated wood chips into such passage. Passage 32 is in communication with a pressurized blow valve comprising a chamber 40 having a bladed agitator 42 rotatably mounted therein and driven by a motor 43. A discharge orifice 44 is positioned in the end zone of the chamber beyond the agitator through which the agitated pulped chips are forced by the pressure in vessel 20 while the bladed agitator periodically wipes by the entrance to the orifice. A gate valve 46 is positioned in the orifice 44 for adjusting and closing its aperture, and a level sensing means 48 is located at the upper end of vessel 20 for sensing the liquid level 49 therein.

For treating the mass of treated chips by washing them with a countercurrent flow of water, a liquid inlet 24 having a valve 28 for controlling liquid flow therethrough, is provided adjacent the bottom of the tower and a strainer 26 having a control valve 27 adjacent the top thereof. Thus, cool liquid can be introduced at the bottom of the tower and passed upwardly through the slowly descending chip mass and discharged in heated condition at strainer 26. This arrangement not only provides uniform chip washing, but also creates a temperature stable environment for the washing and one which is uniquely compatible with that of the reaction vessel with which it is in direct pressure and temperature communication through conduit 22.

The reaction vessel 50 is fed a pressurized solid particle-liquid mixture by any suitable means such as a positive feed pump to prevent backflow, a pump such as that shown in Patent No. 2,908,226 being entirely suitable. As is explained in Patent No. 2,878,116, the pressurized mixture is fed into the lower end of reaction vessel 50 and is fed upwardly therethrough by a rotatable and reciprocally helical chip lifter member 52. The member 52 is mounted for rotation and reciprocation on its shaft 53 and cooperates within vessel 50 into which is fed the solid particle-liquid mixture, the mixture entering the vessel through an opening located generally centrally of member 52. A strainer 54 and a discharge means is provided near the upper end of the vessel 50. Reciprocation and rotation of said member, by any suitable means (not shown) serves to move the solid particle component of the mixture upwardly through the reaction vessel independently of movement of liquid in the vessel, the member being foraminous for free passage of liquid therethrough while preventing passage of the solid particles through the member into the lower portion of the vessel therebelow. This structure and its operation being fully described in said Patent No. 2,878,116, will not be further described herein except in relation to the present invention.

At the top of the reaction vessel 50, above the liquid level therein, is provided a discharge means comprising a collecting opening 55 communicating with a downwardly and outwardly extending conduit 21 which opens into the washing and cooling vessel 20. A scraper having a plurality of arms 58 mounted on a downwardly extending vertical shaft 59 driven by a suitable motor is provided for moving the treated chips or other particles into opening 55, the level of the liquid being maintained well below said opening so that the chip mass extending above said level will be drained of liquid by gravity so that the only liquid carried into conduit 21 is that absorbed by and carried on the surface of the treated chips themselves. The treated chips pass down conduit 21 and directly into the washing and cooling downflow vessel 20, such vessels being in direct pressure communication with one another through said conduit.

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In more detail as to the operation of the diffusion washing vessel 20, its digested wood chips are fed from the vessel 50 through the conduit 21 and are thereafter fed downwardly by the tamping arms 31. The scraper 34 scrapes the washed and cooled chips off from the bottom of the compacted chip mass at exactly the rate at which the chip mass progresses downward. The chips are thereafter moved toward the center of the vessel into the outlet 32 by combination of the mechanical action of the blades on the scraper and of the sluicing by excess liquid introduced into the liquid inlet 24. The water supply at such inlet thus, in effect, includes two flows; one being the cold water supply required to wash the chips, all of which comes out of the top of the vessel at strainer 26 and its valve 27 as hot liquid, and the second of which is the additional cold water required to sluice the chips down through the central opening 32 and into the agitator and the valve 46 at a desired consistency which is a function of the power consumed by the bladed agitator. This can be determined for all practical purposes by the required current to motor 43, the current as measured by sensor 45 and hence the power required increasing with increasing consistency. The control of the wash water input through inlet 24 may be set as desired to give a predetermined rate. The level device 48 operates valve 27 to maintain the level as desired.

To control the consistency, for example, to decrease it, it is only necessary to add more cold water through inlet 24 by further opening valve 28. Valve 46 is also opened further to take the added water as well as the digested pulp out of the system through discharge orifice 44. To increase the consistency, the reverse is carried out.

Automatic operation of the system may be provided in a variety of ways by utilizing the available control elements such as the liquid level sensing means 48, the motor current sensor 45, and valves 27, 28 and 46.

If desired, the liquid outlet valve 27 could be set at a predetermined value and the level sensing means 48 connected and arranged automatically to operate valve 28 controlling the flow of cool liquid into liquid inlet 24.

Fully automatic operation can be provided by controlling either the liquid inlet valve 28 or the pulp output gate valve 46 by means of the power requirements of motor 43 as measured by its sensor 45, this latter being shown and described specifically in co-pending patent application, Serial No. 198,558, filed May 29, 1962, a continuation-in-part of patent application, Serial No. 805,503, filed April 10, 1959, and now abandoned, said applications having a common assignee with the present application.

FIG. 4 shows such an arrangement with pulp output valve 46 wherein an ammeter, wattmeter, or the like, operates as the sensor 45 placed in the power line 91 connected to the motor 43. Said sensor is connected so as to deliver a signal to an air pilot valve 92, of a type well known in the art. The sensor output signal, for example from an ammeter sensor, is related to the energy being consumed by motor 43, which is an indication of the resistance to rotation encountered by the agitator 42. With an increase in the ammeter signal, pilot valve 92 increases the air pressure in valve-actuating lines 94, which opens the pulp output gate valve 46. A decrease in the signal similarly decreases the setting of the valve. By so utilizing the arrangement of FIG. 4 in the system of FIG. 1, continual automatic operation of the apparatus is achieved to provide constant washing and constant consistency. FIG. 5 shows a modification wherein the inlet valve 28 is substituted as the controlled valve. It operates in essentially the same manner.

Another possibility would be to control the pulp output valve 46 directly from the level control means, with the liquid inlet and outlet valves preset.

A major feature of the invention is that the down-feeding means including elements 31 need not be syn-

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chronized with other feeding means in the system. The stroke length and stroking frequency can be fixed to accept the maximum expected rate of feed, but at lower feed rates it will compact and advance the chips only as fast as they are received from inlet 21. This same characteristic is also true of other elements in the system, namely, chip lifter 52, scraper 58, and scraper 34. Thus complicated synchronization of these elements is not necessary.

The various automatic control means herein discussed are well understood by those skilled in the control art and need not be further explained herein other than to point out their basic interconnections as has been done in FIG. 1.

Thus it will be seen that the invention provides novel downflow washing vessels and systems incorporating same. Various modifications of the invention within the spirit thereof and the scope of the appended claims will be apparent to those skilled in this art.

What is claimed is:

1. Wood chip washing apparatus comprising a generally upright elongated washing vessel having an inlet adjacent its upper end for receiving treated wood chips, tamper means mounted adjacent the upper end of said vessel and positioned adjacent said inlet for advancing the treated wood chips downwardly through said washing vessel substantially independently of the movement of liquid in said washing vessel, means for feeding washing liquid into said washing vessel adjacent the lower end thereof, moving it in an upward direction through said vessel and discharging it adjacent the upper end of said vessel, and discharging means for discharging washed treated chips from the lower end of said vessel.

2. Wood chip washing apparatus as claimed in claim 1 wherein said discharging means includes pulp valve means for controlling the discharge of said treated wood chips.

3. Wood chip washing apparatus as claimed in claim 2 wherein said means for feeding washing liquid includes a liquid inlet adjacent the bottom of said vessel, liquid inlet valve means for controlling the inlet of liquid, and a liquid outlet adjacent the top of said vessel.

4. Wood chip washing apparatus as claimed in claim 3 further including level control means connected and arranged to maintain a liquid level in said vessel above said liquid outlet and below said means for advancing the treated wood chips downwardly.

5. Wood chip washing apparatus as claimed in claim 4 wherein said level control means controls said liquid inlet means.

6. Wood chip washing apparatus as claimed in claim 4 wherein said level control means controls said pulp valve means.

7. Wood chip washing apparatus as claimed in claim 4 further including liquid outlet valve means and wherein said level control means controls said liquid outlet valve means.

8. Wood chip washing apparatus comprising a generally upright elongated pressurized washing vessel having an inlet adjacent its upper end for receiving treated wood chips, tamper means mounted adjacent the upper end of said vessel and positioned adjacent said inlet for advancing the treated wood chips downwardly through said washing vessel substantially independently of the movement of liquid in said washing vessel, means for feeding washing liquid into said washing vessel including a liquid inlet adjacent the bottom of said vessel, liquid inlet valve means for controlling the inlet of liquid, and a liquid outlet adjacent the top of said vessel, and discharging means for discharging washed treated chips from the lower end of said vessel including pulp valve means for controlling the discharge of said treated wood chips.

9. Wood chip washing apparatus as claimed in claim 8 wherein said discharge means includes a bladed agitator,

power means for rotating said agitator, and power input sensing means.

10. Wood chip washing apparatus as claimed in claim 9 wherein said power input means controls said liquid inlet valve means for controlling the input of washing liquid. 5

11. Wood chip washing apparatus as claimed in claim 9 wherein said power input means controls said pulp valve means to maintain uniform consistency.

12. Wood chip washing apparatus as claimed in claim 10 10
11 further including level control means connected and arranged to control said liquid inlet valve means for controlling the input of washing liquid.

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