

June 4, 1974

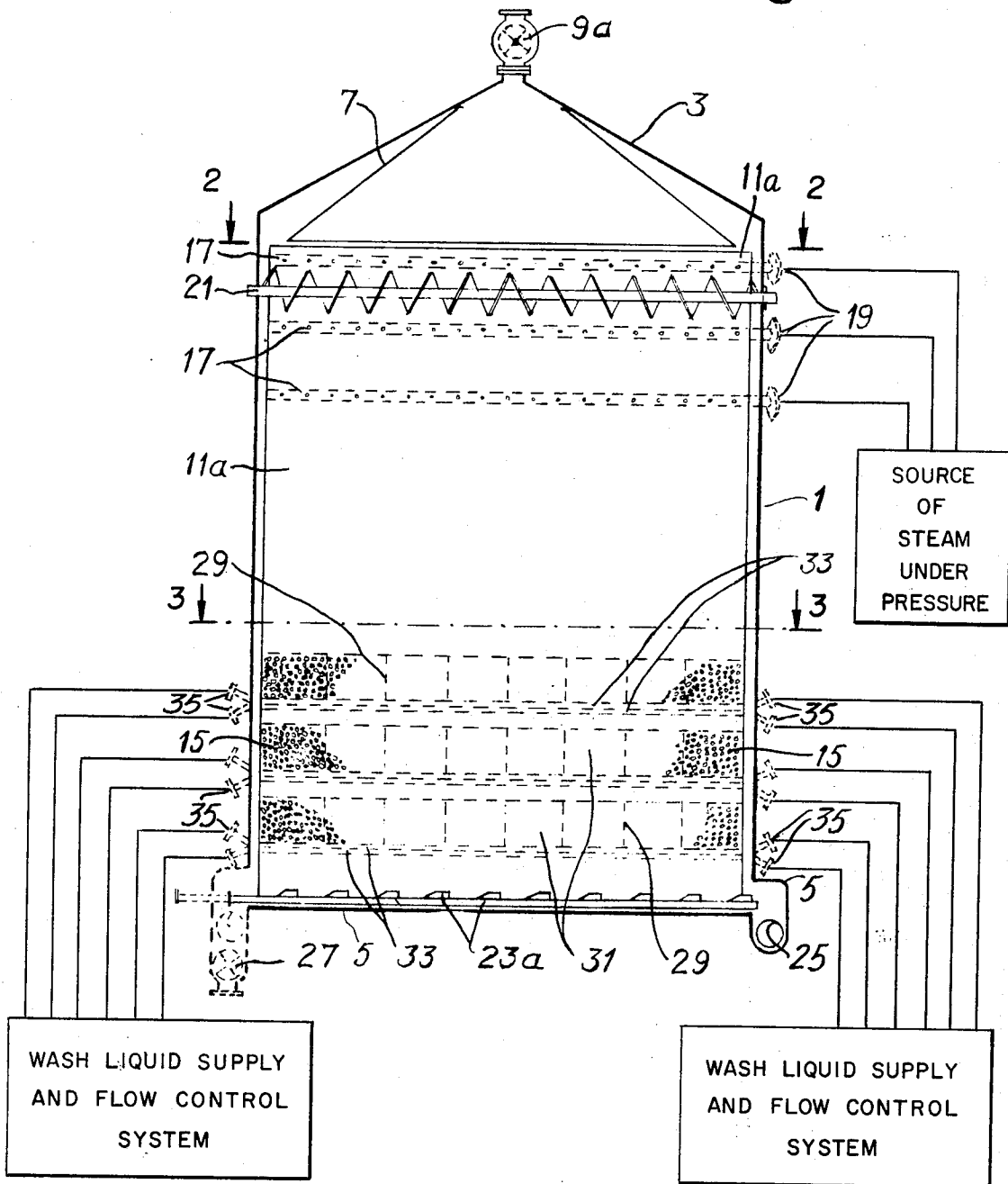
G. I. INGEMARSSON
METHOD AND APPARATUS FOR THE CONTINUOUS
DIGESTION OF CELLULOSIC MATERIALS

3,814,663

Filed Nov. 26, 1971

4 Sheets-Sheet 1

Fig. 1



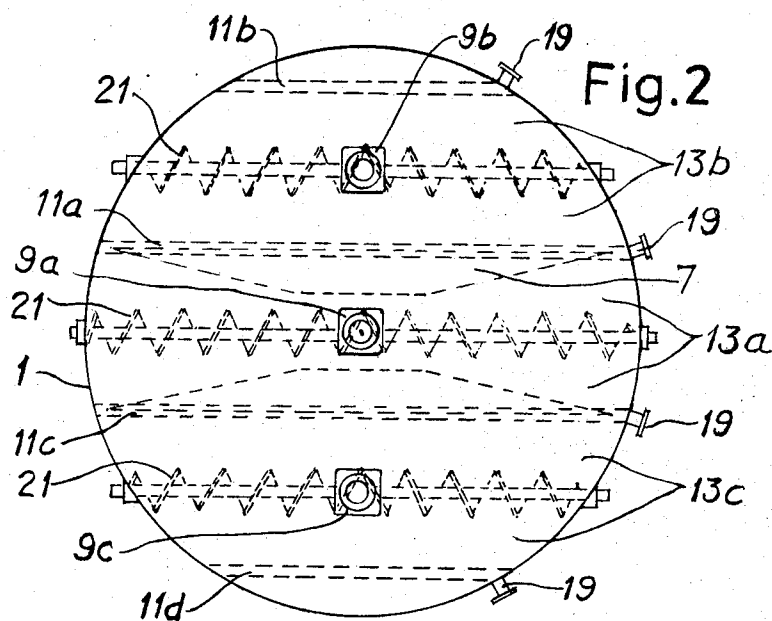
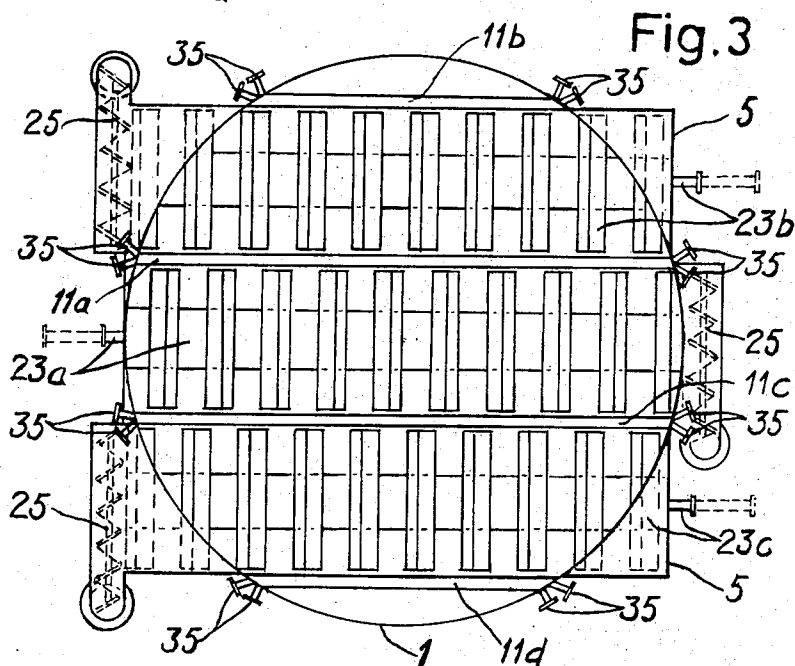
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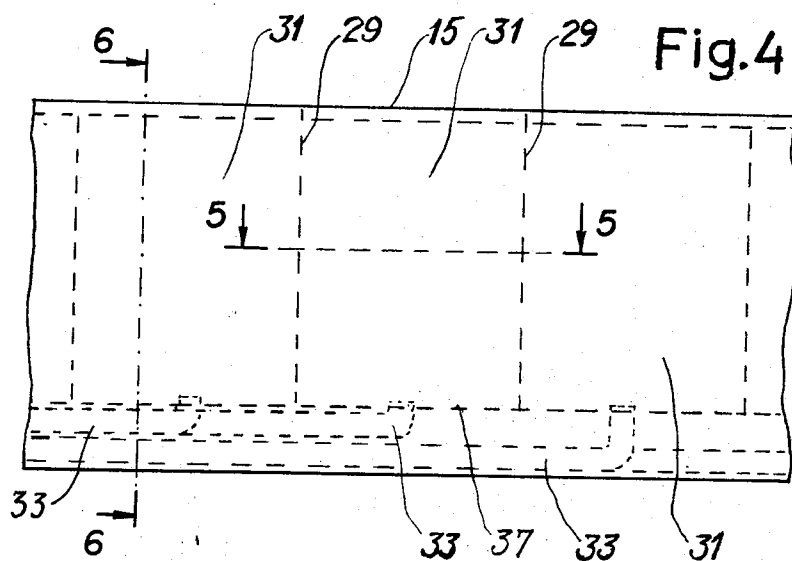
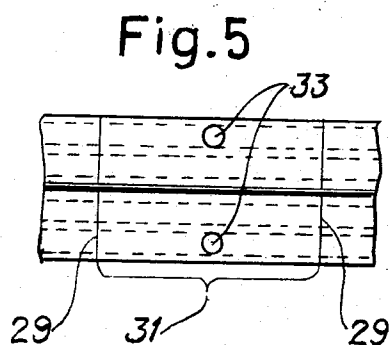
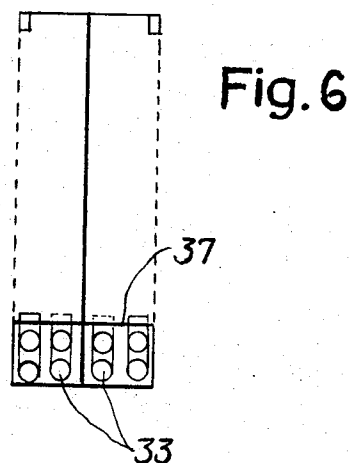
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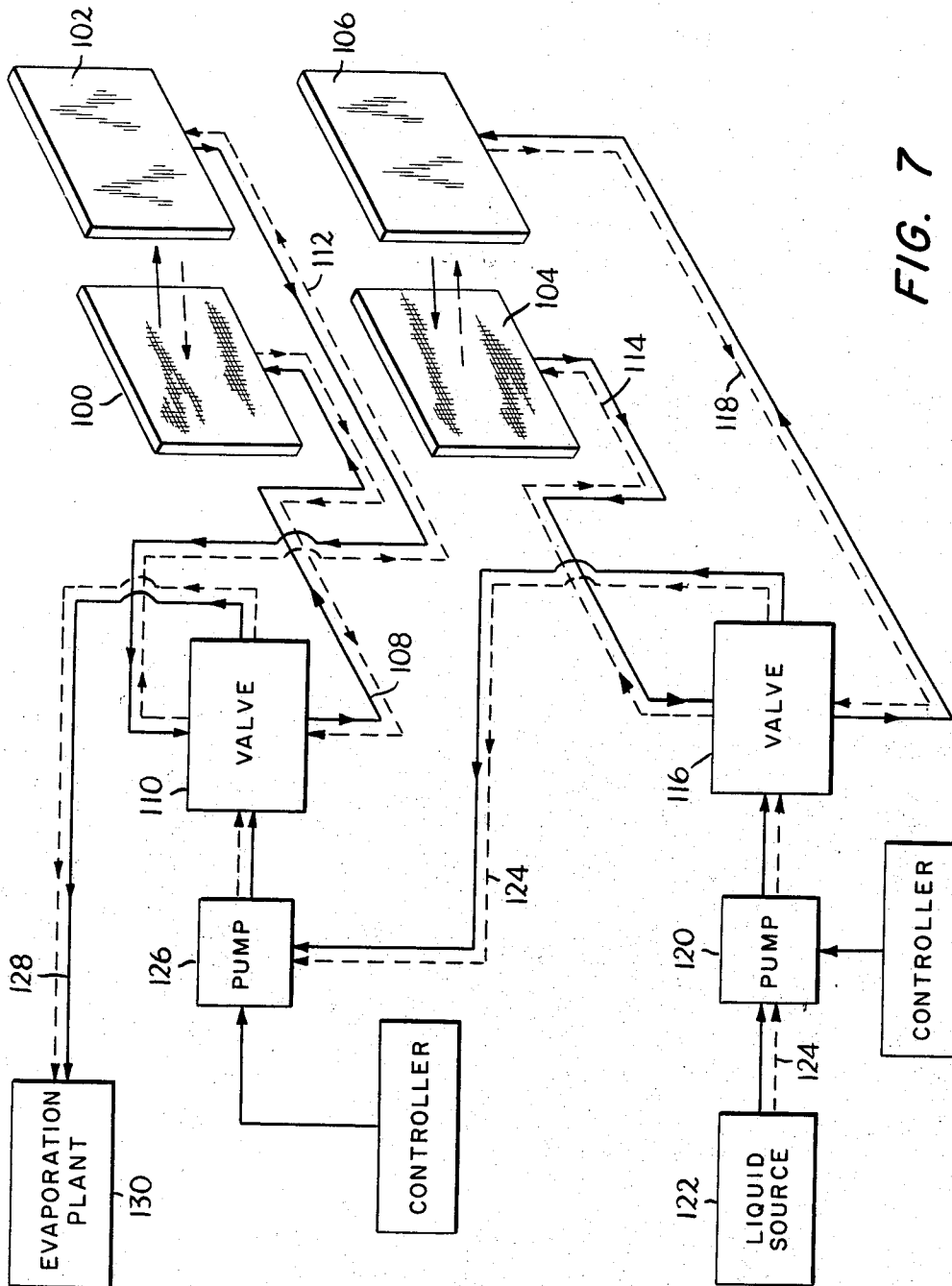
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METHOD AND APPARATUS FOR THE CONTINUOUS DIGESTION OF CELLULOSIC MATERIALS
Gosta Ingemar Ingemarsson, Karlstad, Sweden, assignor to Aktiebolaget Karlstads Mekaniska Werkstad, Karlstad, Sweden

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16,095/70, 16,096/70
Int. Cl. D21c 7/00, 9/02

U.S. Cl. 162—60

17 Claims

ABSTRACT OF THE DISCLOSURE

Cellulosic materials are continuously digested and subsequently washed with a liquid to produce a pulp in a closed, substantially straight vessel having at least one partition structure within it and extending generally transversely and substantially longitudinally of the vessel to divide it into at least two generally longitudinally extending compartments. Steam is introduced into the upper part of the vessel for digestion of the material, and a washing liquid is introduced separately under controlled conditions into the respective compartments to wash the material. Cellulosic materials which have been pretreated with chemicals that promote digestion are introduced separately into each compartment and are withdrawn separately from each compartment at controlled rates.

BACKGROUND OF THE INVENTION

This invention relates to the digestion and subsequent washing of cellulosic material in the production of pulp.

A common, known way of digesting and washing cellulosic materials, such as wood chips, in the production of pulp is continuously to conduct the wood chips into the top of a vertical, cylindrical liquid-filled digester vessel. The chips are impregnated with chemicals in the top part of the vessel, are digested in a heated section of the vessel below the impregnating section, and are finally washed by conducting a washing liquid through the material at the bottom of the vessel. The success of such a continuous digestion process requires that the chips move downwardly at a relatively constant speed over the entire cross-section of the digester so that the residence time of all chips at any given level remains constant and so that even temperatures, chemical concentrations and liquid flow conditions are the same throughout any given cross-section. Various devices for meeting these requirements have been embodied in the designs provided heretofore and represent part of the present knowledge in this art.

One condition of particular importance in a continuous digestion process is that the liquor be washed out of the digested material to the greatest extent possible. A maximum washing effect can be obtained only if the body of cellulosic material in the washing zone of the digester vessel is sufficiently concentrated or compacted such that the resistance to liquid flow through the digested chips is essentially equal to the resistance to the flow of washing liquid through spaces in between the chips. In other words, if the pulp mass is not sufficiently concentrated to provide a high resistance to a liquid flow condition in which wash liquid by-passes the chips, then the liquid will tend to flow around the chips rather than

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through them and, therefore, provide a generally unsatisfactory washing.

It has been determined that the concentration of the digested material in the washing zone of the vessel should be such as to provide a fiber content of about 25 to 30 percent dry weight of fibers to the total weight of fibers and liquid. The concentration of the mass of chips in the washing zone of the vessel is, of course, a function of the difference between the specific gravity of fully impregnated chips and the specific gravity of the cooking liquor under the conditions in the digester. These values for normal sulfate digestion processes are generally about 1.05 and 0.9, respectively. Accordingly, the desired concentration (25 to 30%) of the chips in the bottom of a digester filled with a liquid would require a column of chips and liquor to a height of from about 60 to about 80 meters. This, of course, means that a vessel of extremely great height is required.

Another aspect of a continuous digestion and washing process for producing pulp from wood chips or other cellulosic materials is the difficulty of impregnating highly moistened wood chips at the top of the vessel with a sufficient amount of the appropriate chemicals to promote digestion effectively. Accordingly, digestion takes place in a liquid phase which involves a degree of further diffusion of chemicals into the chips. This means, again, that the height of the digester vessel must be sufficient to allow for such additional chemical diffusion into the moist chips supplied to the vessel.

Another problem with presently known continuous digesters is that the flow of liquids in the vessel is generally in the radial direction. This makes it theoretically impossible to establish an even rate of flow and an even distribution of temperature across any given cross-section of the digester. In practice, it is possible in various ways to come close to achieving fairly even temperature and flow conditions in a given cross-section. On the other hand, the degree to which the desirable flow and temperature conditions in a given cross-section of a digester can be obtained is diminished as the diameter of the digester vessel is increased.

For the reasons given above and for various other reasons, the continuous digesters that are in use presently are necessarily designed for a specific process carried out on a given time schedule. Any changeover to different process conditions, or to the operation of a somewhat different digestion process in a given vessel, or to the use of a given vessel for carrying out a two-stage digestion process can be achieved only with difficulty, if at all. In other words, the presently known continuous digesters are relatively inflexible as to the process conditions and the materials with which they can be used.

SUMMARY OF THE INVENTION

There is provided, in accordance with the invention, a method and an apparatus for continuously digesting cellulosic material, such as wood chips, and for subsequently washing the cellulosic materials to produce pulp. The method and apparatus of the invention represent very significant improvements in the presently known technology in that they provide continuous digestion more cheaply than with present techniques and allow significant variations in the particular process conditions so that a single vessel can be used to produce a variety of pulps from a variety of raw materials.

In the method and apparatus of the invention, digestion of a cellulosic material, such as wood chips, takes place in a gas phase, which means that a column of chips of a height of only about 10 meters will provide a concentration of chips of about 25 to 30% at the bottom of the digester, the condition mentioned above that is necessary for effective washing of the digested chips. Accordingly, a vessel of very substantially less height than required in previously known processes can be used.

More particularly, in accordance with the invention, a cellulosic material is continuously digested and subsequently washed in a closed substantially straight vessel which is divided into at least two generally longitudinally extending compartments by at least one partition structure within the vessel and extending generally transverse-ly and substantially longitudinally of the vessel. The chips are delivered to each compartment of the vessel separately at a controlled supply rate, and the digested and washed pulp is removed separately from each compartment at the other end of the vessel at a controlled rate.

The vessel is preferably positioned with its longitudinal axis substantially vertical so that the raw material to be treated is introduced at the top and the digested and washed pulp is withdrawn at the bottom. Steam is introduced into the top of the vessel and, preferably, all of the compartments in the vessel communicate in the top portion thereof so that an essentially balanced steam atmosphere exists in the upper portion of all compartments of the vessel. To ensure even distribution of the raw material at the top, a spreading device is provided in the top portion of each compartment. Similarly, the removal of digested and washed pulp at the bottom of the vessel is provided by a scraper device that takes generally even, successive, horizontal layers of pulp from the compartment and conducts them out through outlets in the sides of the bottom portion of the vessel.

The digested cellulosic material is washed in the bottom portion of each compartment of the vessel by conducting washing liquid transversely across each compartment. Preferably, the washing liquid is supplied in one side of each compartment and removed from the other side of each compartment by liquid chambers built into the lower part of the partition structure. The liquid supply and withdrawal chambers in the partitions include screens constituting the walls of the partition structure facing each compartment.

In a preferred embodiment, each compartment has a multiplicity of washing zones, and the wash liquid supply for each zone is separately controlled to provide an even distribution of wash liquid throughout the mass of material in each washing zone. To this end, the liquid supply and withdrawal chambers in each partition structure are subdivided both vertically and horizontally into separate non-communicating chamber sections, such sections on opposite sides of each compartment being generally co-extensive. Liquid is separately supplied and separately withdrawn from the matching chamber sections on either side of each compartment so that temperature and flow conditions throughout the entire washing zone are closely controlled.

In the method of the invention, which employs the apparatus described generally above, the cellulosic material to be digested and washed in the vessel is pre-treated previously to being introduced into the vessel to impregnate it with the appropriate chemicals for promoting digestion. Accordingly, digestion takes place in a gas environment provided by the introduction of steam under pressure substantially above atmospheric in the top portion of the vessel. As mentioned above, the concentration of pulp in the washing section of the vessel required for effective washing can be obtained with a relatively short column of chips, inasmuch as there is no buoying effect on the chips in the column due to the presence of a liquid in the upper part of the vessel. This means that a vessel of a relatively low height can be used, which in turn

significantly reduces the cost of the vessel, as mentioned above.

The partition structure in the vessel affords additional mechanical strength to the vessel, which makes it feasible and economical to construct relatively large diameter vessels. The partitioning of the vessel also provides the important practical advantage of providing relatively short transverse distances for washing liquid to flow across, which in turn makes it easier closely to control the washing conditions.

The provision of separate compartments in the vessel makes it possible for different cellulosic materials to be treated or to provide different treatment processes to produce different grades of pulp. For example, the residual lignin content or the degree of polymerization in various compartments of the vessel can be varied rather widely. Variations in the processing conditions, notwithstanding the maintenance of the same pressure and steam temperature in various compartments of the vessel, is afforded by providing different pre-treatments of the raw materials supplied to the digester vessel and by varying the flow rates in the various compartments. For example, semi-chemical hardwood pulp can be produced in one compartment and pinewood sulfate pulp in another compartment. Similarly, sawdust could be treated in one of the compartments of the vessel. It is also entirely possible for a two-stage digestion process to be carried out by conducting one stage in one compartment of the vessel, removing the material from the bottom of that compartment and introducing it to the top of another compartment for a second stage of treatment.

DESCRIPTION OF THE DRAWINGS

For a better understanding of the invention, reference may be made to the following description of an exemplary embodiment, taken in conjunction with the figures of the accompanying drawings, in which:

FIG. 1 is a view in cross-section taken generally vertically through an exemplary digester, the view being in generally schematic form;

FIG. 2 is a view in transverse cross-section taken near the top of the vessel of FIG. 1, as represented by the lines 2—2 in FIG. 1;

FIG. 3 is a view in transverse cross-section of the vessel of FIG. 1 taken near the bottom of the vessel along a plane represented generally by the lines 3—3 in FIG. 1;

FIG. 4 is a side elevational view of one wash liquid chamber associated with one of the partitions in the vessel of FIGS. 1 to 3, the view being on an enlarged scale, relative to FIGS. 1 to 3, and showing only the wash chamber construction;

FIG. 5 is a top view in cross-section of a typical section of a wash chamber, the view being taken generally along a plane represented by the lines 5—5 in FIG. 4 and in the direction of the arrows;

FIG. 6 is an end view in cross-section of a section of a wash chamber, the view being taken generally along a plane represented by the lines 6—6 in FIG. 4 and in the direction of the arrows, and

FIG. 7 is a schematic diagram showing a system for supplying wash liquid to a typical section of a wash chamber.

DESCRIPTION OF THE EXEMPLARY EMBODIMENT

A digesting vessel, according to the embodiment shown in the drawings, comprises a vertical cylindrical shell 1 provided with a conical top part 3 and three rectangular bottom sections 5. In the conical top part 3 there are guide plates 7 for spreading into a layer impregnated wood chips that are fed into the digesting vessel through three rotary vane feeders 9a, 9b and 9c. The digesting vessel

has four transverse, longitudinal partitions 11a, 11b, 11c and 11d, which divide the vessel into three compartments 13a, 13b and 13c (FIG. 2). Screening devices 15 built into the lower part of each partition 11a, 11b, 11c and 11d are in the form of boxes defining chambers that extend horizontally across the digesting vessel, the sides of such chambers which face the compartments 13a, 13b and 13c being perforated. In the upper part of the partitions 11a, 11b, 11c and 11d there are distribution conduits 17 that extend horizontally across the digesting vessel and have outlets opening inside the compartments 13a, 13b and 13c being perforated. In the upper part of the partitioned connected piece 19 mounted outside the vessel. In the top part of each compartment 13a, 13b and 13c is a spreader screw 21 for evening out material supplied to the vessel. The bottom section 5 of each compartment 13a, 13b and 13c is equipped with a so-called stoker device 23a, 23b and 23c in the form of a conveyor with blades that move along the bottom area of the compartments 13a, 13b and 13c and take a layer of material off the bottom of the mass in the vessel. At the discharge end of the stoker devices 23a, 23b and 23c are a feed screw 25 and a rotary vane feeder 27 at the discharge end of each screw for removing pulp from the vessel.

As may best be seen in FIGS. 4 to 6, the screening devices 15 are divided by vertical partitions 29 into a plurality of sections 31. Each section 31 is connected by a pipe 33 to a flanged connector piece 35 outside the digesting vessel. The pipes 33 run to each section 31 in a space under a bottom plate 37 arranged in the bottom part of the screening devices 15, as shown in the drawings.

The digesting vessel operates in the following manner. Wood chips impregnated with all the chemicals necessary for digestion in the vessel are fed in through the rotary vane feeders 9a, 9b and 9c. The digesting vessel can be supplied through the three feeders 9a, 9b and 9c with chips impregnated with three different kinds of chemicals, which are directed by the guide plates 7 to the different compartments 13a, 13b and 13c, so that each compartment only receives one kind of chips. The chips are spread out to an essentially horizontal level in each compartment 13a, 13b and 13c by means of the spreader screws 21. The level of chips in each compartment is regulated in a known way by level sensing elements (not shown), which control the speed of the rotary vane feeders 9a, 9b and 9c. The heat necessary for digestion is supplied to the vessel by delivering steam under pressure through the conduits 17 from a source connected to the conduits. The supply of steam is, of course, controlled by sensing the temperatures at appropriate places in the vessel and controlling the supply of steam accordingly. The retention time for the wood chips in the digesting vessel is regulated in ways that are well known to those skilled in the art and that includes controlling the speed of the stoker devices and the speed of the rotary vane feeders 27 at the outlet.

In the bottom part of each compartment 13a, 13b and 13c wash liquid is supplied and removed, so that liquid is maintained in the vessel to a level somewhat above the uppermost screening device 15. Each compartment 13a, 13b and 13c thus comprises a top digesting zone, where the chips are digested in a steam atmosphere, and a bottom washing zone, which is filled with liquid and where released wood substances are washed out by countercurrent washing.

Washing of the digested material is effected by pumping the wash liquid in through the supply pipes at a pressure exceeding the pressure in the digesting vessel. Fresh wash liquid is pumped into the lowest screening device 15 on one side of each compartment 13a, 13b or 13c, flows across the respective compartment, and is drawn off from the lowest screening device 15 opposite it on the opposite side of the respective compartment 13a, 13b or 13c. The wash liquid is thus caused to flow horizontally across the

respective compartment 13a, 13b or 13c and displaces the liquid with which the chips are then saturated. After the wash liquid has flowed, for example, from the lowest screening device 15 in the partition 11a through the compartment 13b to the lowest screening device 15 in the partition 11b, it is withdrawn from that screening device and is pumped into the next lowest or center screening device 15 in the partition 11a. From the center screening device 15 the liquid flows horizontally again to the center screening device 15 in the partition 11b. The wash liquid is then pumped to the uppermost screening device 15 in the partition 11a, flows across to the uppermost screening device in the partition 11b, and since it has become intermixed with the released wood substances, it is pumped away to the evaporation plant. To ensure a uniform displacement of liquid in the washing zone, i.e., to prevent the occurrence of so-called channelling, or the possibility that certain parts of the digested wood chips in the respective compartments 13a, 13b and 13c are washed less effectively, than other parts due to the resistance to flow being changed in the screen plates of the screening device 15 or in some other way, a prescribed quantity of wash liquid is pumped into each supply screening device per unit of time by volumetric pumps associated with each section 31 of the screening device 15. In a corresponding way, an equal quantity of liquid is drawn off per unit of time from each section 31 of the oppositely located screening device 15 on the other or discharge side of the respective compartment 13a, 13b or 13c. By this means the flow paths of the wash liquid will always be essentially horizontal and parallel and the rate of flow constant across the whole cross-section of each compartment in the digesting vessel. The pumps and control devices for controlled admission and extraction of wash liquid are, of course, connected in a piping system associated with the flanged connector pieces 35. These devices and the piping outside the digesting vessel for conveying the liquid between the different screening devices are matters of routine engineering skill and, therefore, not shown on the accompanying drawings or described in detail, apart from the block representation in FIG. 1 of the drawings and the schematic diagram in FIG. 7. Since the flow of digested chips vertically from one screening device to another takes place during a long period of time, this can cause packing of the chips against the screening device receiving the liquid and clogging of the screen plates. The liquid conducting system is, therefore, preferably designed for reversal of direction of flow while retaining the desired concentration gradient in the vertical direction of the digesting vessel.

FIG. 7 of the drawings illustrates schematically an example of the washing arrangement employed in the apparatus shown in FIGS. 1 to 6 of the drawings. The reference numerals 100, 102, 104 and 106 of FIG. 7 represent individual sections of the screening device associated with one compartment of the vessel (see also the compartments 31 shown in FIGS. 1 and 4 to 6 of the drawings). In FIG. 7, the sections 100 and 102 are located opposite each other and above the sections 104 and 106. Each screening device section is connected by pipes (see also pipes 33 of FIGS. 4 to 6) via suitable valves, as described immediately hereinafter. The positions of the valves and the flow paths of wash liquid through the piping system in one direction are indicated by solid lines while the position of the system for flow in the other direction is represented by dashed lines. Arrows are applied to both forms of line to indicate the flow paths more clearly. The flow path in the direction indicated by solid lines begins at a source of wash liquid 122 and involves pumping wash liquid by a controlled pump 120 from the source along the solid line path 118 to the screening device section 106, across the compartment (as illustrated by the solid line) to section 104

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through the solid line path 114 and via the valve 116 through path 124 to a pump 126. The wash liquid is then pumped across the upper zone of the compartment along a path through a valve 110 along the path 108 to the section 100, across the upper zone of the compartment of the section 102 and is discharged along path 112 via the valve 110 and path 128 to the evaporation plant 130. Flow in the reverse direction across the respective zones is, as stated above, illustrated by the dashed lines in FIG. 7, the dashed line illustration being self-explanatory and making it unnecessary to provide a description here.

The admission of wash liquid to the compartments 13a, 13b and 13c is designed to be controlled in a definite ratio to the production of digested chips, while liquor extraction is designed to be controlled to maintain the desired liquid level.

The lowest screening devices 15 in the respective compartments 13a, 13b and 13c can also be used to supply cooling liquid, such liquid being pumped in at both sides of the compartments 13a, 13b and 13c in a quantity equal to the discharged chips-liquid quantity and controlled so that a constant temperature is maintained in the discharged suspension of digested and washed chips from the respective compartments 13a, 13b and 13c.

The digested and washed wood chips are swept from the bottom of the vessel by the stoker devices 23a, 23b and 23c to the feed screws 25, which in their turn feed the chips to the rotary vane feeders 27 that discharge them from the device.

The embodiment of the invention described above and illustrated in the drawings is intended to be exemplary, and many variations and modifications of it will be apparent to those skilled in the art without departing from the spirit and scope of the invention. All such variations and modifications are intended to be included within the scope of the invention as defined in the appended claims.

I claim:

1. A method for continuously digesting and subsequently washing a cellulosic material that has previously been impregnated with chemicals promoting digestion to produce a pulp comprising the steps of essentially continuously introducing materials separately into the top part of each of at least two vertical compartments in a vertical compartmented closed common pressure vessel, introducing steam under a pressure substantially above atmospheric pressure into the top parts of the vessel compartments to promote digestion of the material in a vapor environment, repeatedly conducting a washing liquid transversely across the lower part of each of the compartments at different levels beginning at a lower level and working upwardly separately to wash the material in each compartment and essentially continuously withdrawing the digested and washed pulp from the bottom of each compartment.

2. A method according to claim 1 wherein the top parts of the vessel compartments are in communication with each other so that the materials in both compartments are treated at substantially equal steam pressures.

3. A method according to claim 1 wherein the materials introduced into the respective compartments are pretreated with different chemicals.

4. A method according to claim 1 wherein the materials introduced into the respective chambers are of different kinds.

5. A method according to claim 1 wherein the rates of introduction and withdrawal of the materials are different for the two compartments so that the residence times of the materials in the two compartments are different from each other.

6. A method according to claim 1 and further comprising the steps of separately conducting wash liquid across each compartment at separate horizontally ad-

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jacent zones and controlling the rates of wash liquid flow separately for each zone.

7. Apparatus for the continuous digestion and subsequent liquid washing of cellulosic material comprising a closed essentially straight vessel, positioned with its longitudinal axis substantially vertical, at least one partition structure within the vessel and extending generally transversely and substantially longitudinally of the vessel and dividing it into at least two generally longitudinally extending compartments, means at the upper end of the vessel for supplying separately to each compartment a material to be digested and washed, means for introducing and maintaining steam under pressure in a portion of the vessel adjacent the upper end thereof to promote digestion of the material, means for separately conducting wash liquid transversely to the partition structure through a lower portion of each compartment to wash separately material contained in each such compartment, and means at the lower end of each compartment for removing separately from each compartment the digested and washed pulp.

8. Apparatus according to claim 7 wherein an upper part of the partition structure is gas permeable, whereby the upper parts of both compartments are maintained at an essentially uniform steam pressure.

9. Apparatus according to claim 8 wherein the partition structure ends below the top of the vessel.

10. Apparatus according to claim 1 wherein the supply means includes a distributor device for spreading the material generally evenly across the top of each compartment.

11. Apparatus according to claim 7 wherein the discharge means includes a scraper device for taking generally even successive horizontal layers of pulp from the bottom of each compartment and discharging them from the vessel.

12. Apparatus according to claim 7 wherein the means for conducting wash liquid through the compartments provides wash liquid flow generally horizontally through the mass of pulp therein in a direction generally transverse to the partition structure.

13. Apparatus according to claim 7 wherein there are at least three partition structures defining at least two vertical compartments of generally equal width transverse to the partition structures, and wherein a lower portion of each partition structure includes at least one chamber for supply and withdrawal of a wash liquid, each chamber having a screen in its wall facing the respective compartment and communicating the chamber with the compartment for supply or withdrawal of wash liquid to or from the compartment.

14. Apparatus according to claim 13 wherein the lower portion of each partition structure includes a multiplicity of separate chambers and means for supplying or withdrawing liquid to or from each chamber individually.

15. Apparatus according to claim 14 wherein each partition structure includes at least one lower chamber and one upper chamber arranged vertically above the lower chamber, the respective upper and lower chambers in each partition structure being generally coextensive with corresponding upper and lower chambers in the partition structure opposite it across the respective compartment, and further comprising means for delivering wash liquid to the lower chamber on one side of each compartment, means for withdrawing the wash liquid from the lower chamber of such compartment opposite it, means for conducting such withdrawn liquid from said lower chamber to the upper chamber on one side of the compartment and means for withdrawing the wash liquid from the upper chamber on the other side of the compartment.

16. Apparatus according to claim 14 wherein the lower portion of each partition structure includes at least two horizontally adjacent separate chambers, each such cham-

ber being generally coextensive with a corresponding chamber in the partition structure on the opposite side of the respective compartment, and further comprising means for separately supplying wash liquid to each of such chambers in the partition structure on one side of each compartment and means for separately withdrawing wash liquid from the corresponding chamber in the partition structure on the opposite side of that compartment.

17. Apparatus according to claim 6 and further comprising means for controlling the supply of wash liquid to each chamber to provide essentially uniform washing of all material in each compartment.

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S. LEON BASHORE, Primary Examiner

R. V. FISHER, Assistant Examiner

U.S. Cl. X.R.

162—17, 237, 248

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,814,663

Dated June 4, 1974

Inventor(s) G. I. INGEMARSSON

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 3, line 40, "in" should be --on--; Col. 5, line 12, delete "being perforated. In the upper part of the parti-" and substitute --of the vessel. Each conduit 17 is fitted with a--; line 13, "connected" should be --connector--; line 55, "includes" should be --include--; Col. 6, line 20, delete the comma (,) after "effectively"; line 25, "device" should be --devices--; Col. 8, line 28, "claim 1" should be --claim 7--; and Col. 9, line 10, "claim 6" should be --claim 16--.

Signed and sealed this 5th day of November 1974.

(SEAL)
Attest:

MCCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents