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CONTINUOUS UPFLOW DIGESTER

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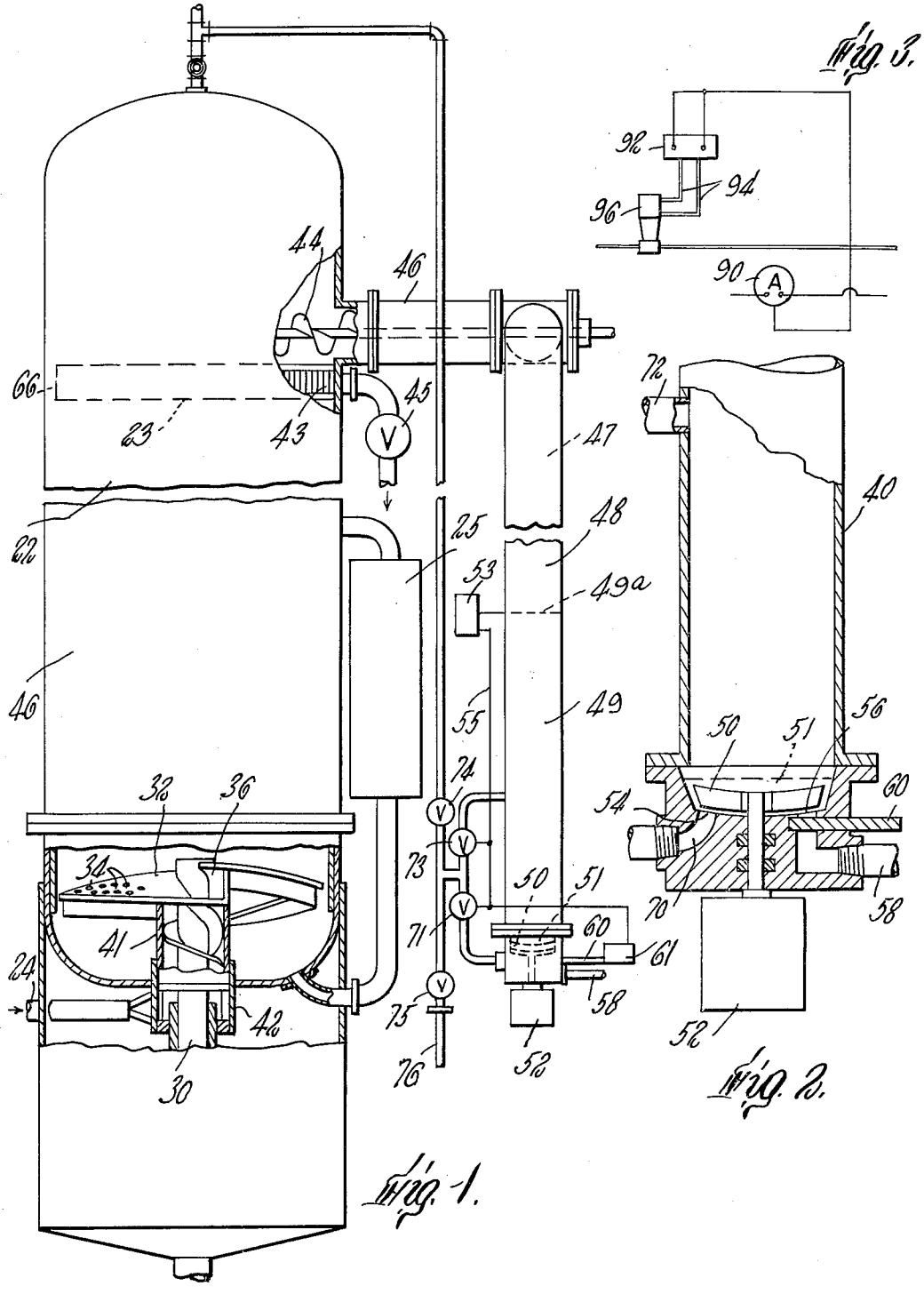


Fig. 1.

Fig. 2.

Fig. 3.

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CONTINUOUS UPFLOW DIGESTER

Lawrence A. Carlsmith, Amherst, N.H., assignor to Improved Machinery Inc., Nashua, N.H., a corporation of Delaware

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This is a continuation-in-part of my application S.N. 198,558 filed May 29, 1962, which is in turn a continuation-in-part of my application S.N. 805,503, filed April 10, 1959, both now abandoned.

This invention relates to the production of pulp from wood chips and more particularly to novel discharge apparatus and methods for a continuous upflow digester, capable of cooking wood chips at high temperature and pressure, draining the cooking or other liquor from the chips while maintaining them at high temperature and under pressure, and thereafter cooling and discharging to atmospheric pressure without flashing the so treated and drained wood chips by adding fluid thereto to aid such discharge.

The discharge of the treated wood chips from a continuous upflow digester of the type shown in Patent No. 2,878,116 has proved to be a problem because of its effect on the operation of the entire digester system as well as upon the treated wood chips themselves and their their subsequent treatment processes. Such a continuous digester may operate at high temperatures and pressures up to 350 degrees F. and 135 p.s.i. steam pressure under typical conditions, and with a digester vessel of the order of 10 feet in diameter and 100 feet in length, produce, say 200 to 300 tons per hour of pulp on air dry basis. Under such conditions, loss of steam which occurs upon discharge of the wood chips into atmospheric pressure is a serious economic consideration, as is the reduction in fiber strength which may be caused by the sudden pressure reduction which occurs during such discharge. But some of the factors present in continuous digestion are, to a degree, in conflict, in that the nature of the chemical process for optimum efficiency requires as high a cooking temperature and hence pressure as possible, but at such high pressure the sudden release of the cooked wood chips from the pressurized digester into atmospheric pressure causes the liquor contained in the wood chips and fibers thereof to "flash" and so damage the fibers by rapid steam release therefrom. Nevertheless the use of a lower cooking temperature necessary to avoid such "flashing" would be detrimental to the cooking process.

According to the present invention, novel continuous pulping discharge apparatus and methods are provided which solve the above recited problems in a unique manner. Specifically, the present invention provides a discharge system for wood chips treated in an upright pressurized elongated reaction or other treating vessel of the type shown in Patent No. 2,878,116, for example, including an upright elongated pressurized wood chip receiver vessel having a substantially smaller cross sectional area than that of the reaction vessel in the range of about 10–50 to 1 but having its upper end in free pressure communication with the upper end of the reaction vessel. As shown in said patent, means are provided for feeding substantially continuously into the lower end of the reaction vessel a wood chip-liquid mixture to maintain a compacted mass of wood chips within an elongated zone in the central and opposite upper end portions thereof and for advancing the wood chips upwardly through said zone at a rate substantially independent of the movement of liquid in said vessel to treat said wood chips at high temperature and pressure, as well as liquid level control means for establishing and maintaining a discrete level in the upper portion of said reaction vessel. Heating

and pressurizing means are provided for maintaining at least the upper portions of the interior of said vessels at a high temperature, substantially in excess of 212 degrees and at a pressure generally least as great as 100 p.s.i., substantially in excess of atmospheric pressure.

In accordance with the principles of the present invention, the elongated upright configuration and relatively small diameter of the receiver vessel is important in order that a wood chip storage zone having stable temperature environment may be created with the top portion of the remover vessel at high temperature while the bottom may remain at a much lower temperature, even less than 212 degrees F. The invention additionally provides conveyance means extending between said vessels adjacent the upper portions thereof for establishing and maintaining a predetermined level of the top of said mass of wood chips above the discrete level of said liquid in said reaction vessel, providing a drainage zone wherein is removed a substantial portion of said liquid from said wood chips producing a high consistency thereof of about 25–35 percent. The conveyance means moves drained cooked wood chips from the reaction vessel to the wood chip receiver vessel wherein is established and maintained a vertically elongated storage zone of high consistency drained cooked wood chips therein, as by means of suitable level sensors and controls. The elongated receiver vessel thus in effect acts as a reservoir of wood chips, in that any non-uniform output from the conveyance means may be temporarily stored therein. It also makes possible the establishment of a temperature insulating zone by reason of said elongated zone of stored treated wood chips, which permits a high temperature to be maintained at the top of the receiver vessel, while a low temperature may be maintained at its bottom end. This makes it uniquely possible to cool the treated wood chips by adding a suitable fluid thereto at said bottom end, preferably a pressurized cool liquid such as water or dilute liquor to provide a cool, somewhat more dilute zone at the bottom of the receiver vessel to prevent "flashing" of the wood chips upon depressurizing at discharge.

The invention also provides means and methods for removing and depressurizing the cooled but still pressurized wood chips directly from the lower end of said zone of high consistency wood chips in said receiver vessel into a substantially lower pressure zone, generally at atmospheric pressure, without "flashing," of the liquid in the pressurized chips. More specifically, such means includes a wood chip discharge orifice adjacent the lower end of the wood chip receiver vessel for discharging pressurized wood chips therefrom, and, preferably, agitator means mounted for rotation within the lower end of the wood chip receiver vessel. The agitator means operates to wipe the orifice and to mix the cool liquid or other fluid introduced through a suitable inlet with said wood chips immediately prior to their discharge in the cooled relatively short and more dilute wood chip zone below said zone of high consistency to aid in their discharge by diluting said wood chips with said added fluid, and, as is generally desired, to reduce the temperature of the wood chips to less than 212 degrees prior to their discharge into said lower pressure zone to prevent substantial "flashing" thereof.

The novel vertical digester-receiver combination of the invention, particularly with an agitator at the bottom for maintaining the wood chips at an agitated state, and equipped with a restrictive discharge orifice adjacent the bottom, has been effective in limiting steam loss, in that a temperature low enough to prevent "flashing" may be established therein by the addition of cool liquid or other fluid, even though the top of the receiver is maintained at a much higher temperature. The agitator by itself

maintains an efficient discharge of the wood chips when supplied at a steady rate by the conveyance means, with the pulp being maintained at a predetermined level at the top of the storage zone as the steam pressure on the top surface of the wood chips partly filling the receiver forces mobile stock through the orifice. But when an unduly high level of wood chips due to an unusually high rate of conveyance burdens the agitator, it has been difficult to maintain the desired operation. The reason for this effect is that with a large depth of wood chips in the receiver as may occur from time to time with a non-uniform discharge from the reaction vessel, most of the pressure drop between the steam pressure on the top surface of the storage zone of wood chips and the pressure on the discharge side of the orifice occurs across the depth of said storage zone. This pressure drop forces the wood chips downwards, compacting them. The compacted zone of high density wood chips offers an extreme resistance to agitation, due to a decrease in mobility. By the downward pressure, this dense mass is jammed down upon the agitator overloading its driver, ultimately stalling it. When this happens, the orifice plugs, since the wood chips are no longer agitated. In fact, the wood chips compact so tightly that no practical increase in driver power can provide for proper operation of an agitator-orifice discharge. However, as taught by the present invention the introduction of the pressurized fluid adjacent the lower end of the receiver uniquely makes it possible to discharge from the reservoir of wood chips temporarily stored in the receiver, even though there may be serious variations in wood chip flow into the receiver, such being aided by control of the orifice and fluid by level sensing means. This aspect of the invention also reduces the power requirements of the agitator driver to permit the use of an economically feasible electric motor, and makes possible automatic load compensation of a rotating agitator subjected to variable flow of wood chips from the bottom of the receiver.

The present invention, then, in one significant aspect, comprises means for admitting to the bottom zone of an elongated receiver vessel, directly connected to a reaction vessel for receiving drained wood chips at high temperature and pressure therefrom, a controlled quantity of low viscosity fluid under sufficient pressure to buffer the downward pulp loading forces imposed on an agitator in response to conditions which tend to halt the operation of the agitator-orifice in order to maintain discharge thereof, such quantity and the discharge orifice opening being under the control of a level sensor if desired.

Another significant aspect of the invention comprises the use of a cool dilute liquor or water as the added fluid, in order to cool the drained wood chips in a zone at the bottom of the receiver to a temperature below about 212 degrees F. to prevent fiber damage caused by "flashing" of the wood chips upon their discharge to atmospheric pressure.

Other objects of this invention will be apparent from the following description of the invention, taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a partially broken away, partially sectional elevation of a preferred embodiment of the invention, showing a vertical upflow digester according to the present invention;

FIG. 2 is a magnified sectional view of a portion of the digester of FIG. 1; and

FIG. 3 is a schematic view of a unique automatic control system adapted to be combined with the digester of FIG. 1 to effect automatic operation thereof.

A preferred embodiment of the apparatus of this invention, as shown in the drawings, includes as its major components an upright pressurized wood chip reaction vessel **22** in combination with a similarly pressurized wood chip receiver vessel **48**, with a conveyance **44** for feeding therebetween at their upper ends. The receiver vessel **48** is of much smaller cross section area than is the reaction vessel of the order of about 10–50 to 1, preferably about 20 to 1 as shown, and has an upward facing bladed agitator **50** rotatably mounted at its bottom and provided with an electric motor agitator driver **52**. A discharge orifice **56** having a control valve **60** and associated controller **61** is positioned in the bottom zone of the receiver vessel **48** preferably beneath the agitator **50** through which orifice agitated wood chips are forced from the vessel **48** by pressure therein with little loss of steam while the bladed agitator periodically wipes by the entrance to the orifice. A lower inlet **70** for pressurized fluid is provided in the bottom zone of the receiver vessel **48** and is spaced from the discharge orifice **56**, while an upper inlet **72** may be positioned thereabove. A source of pressurized fluid is connected with the inlets **70**, **72** through their valves **71**, **73** respectively in series with a valve **74** or **75** positioned in the line of flow source to inlet for controlling the pressurized fluid. A level sensor **53** having connecting wires **55** is preferably provided for actuating the valve **71** or **73** and orifice valve controller **61**. Alternatively, there may be provided a motor load responsive means for operating said valves, which comprises an electrical power responsive monitor operatively connected with the motor power lines and adapted to generate a signal indicating the amount of electrical energy being consumed by the motor, and the valves being responsive to the thus generated signal to control the flow of the pressurized fluid or the orifice opening. Commonly, valve **73** and inlet **72**, if used, maintain a constant fluid flow, with valve **71** being varied by the level sensor or the motor load responsive means.

In FIG. 1 is shown a wood chip reaction vessel **22** of the type described in detail in Patent No. 2,878,116. A strainer **43** having a level or other control valve **45** is located near the top of the reaction vessel to define the upper liquid level therein at **23** and to define the bottom of a drainage zone **66** thereabove so that the cooked wood chips may be drained prior to their removal from the reaction vessel by conveyance **44**, to provide a consistency of about 25–35 percent. Heating and pressurizing means, such as heater **25** is also provided. As described in said patent, the means for feeding continuously into the lower end of said reaction vessel a wood-chip liquid mixture to maintain a compacted mass of wood chips within an elongated zone **46** in said vessel and for advancing the wood chips upwardly through said zone at a rate substantially independent of that of the cooking liquor in said zone includes a foraminous screw means mounted for rotational and reciprocatory movement through a limited distance relatively to the length of the vessel within the reaction vessel **22** near the lower end thereof by means of a shaft **30** extending vertically through the bottom of said vessel generally axially thereof. More specifically, said foraminous screw means comprises a single turn helical plate **32** having therein a plurality of perforations **34** sufficient in number to allow substantially free passage of the liquid therethrough but of small enough size to prevent passage of wood chips or other fibrous material. The step of such helical surface is closed by a flat plate **36** extending vertically between its upper and lower edges and the peripheral edge thereof is positioned closely adjacent the inner walls of the reaction vessel **22** so that passage of chips into the bottom portion of said reaction vessel **22** may be prevented.

For feeding the pressurized mixture of chips and liquid to the upper surface of said plate, a tubular member **41** having its inner wall concentric with and spaced from shaft **30** is mounted on the lower surface of said helical plate **32** extending downwardly therefrom, thus providing a central aperture between the upper and lower radial edges respectively of said helical plate and extending radially from said shaft to said member in the lower portion of the helical surface near said lower edge. Said movable member **41** is positioned closely within a fixed

tubular member 42 mounted in the lower end of reaction vessel 22 and extends both upwardly therefrom to overlap the downwardly extending edge of movable tubular member 41 and downwardly therefrom to provide a connection to inlet line 24.

The screw conveyance 44 located near the top of the reaction vessel 22 is adapted to remove drained wood chips therefrom, to move them through conveyance housing 46, and to discharge them to the elongated receiver vessel 48, of much smaller cross section dimension, say 1/20 of the area of vessel 22, connected through gas-tight fittings to the conveyance housing 46, so that at least the top portions of said vessels are freely interconnected and so similarly maintained at high temperature and pressure. In the bottom surface zone of the receiver vessel 48, generally defined as the volume below the illustrated flanged coupling, an upward facing, bladed agitator 50 is rotatably mounted and operatively connected with a driving means 52, preferably an electric motor. A bottom surface 54 generally conforms with the path of the lower and outer edges of the rotatable blades, to define the lower extremity of the bottom zone. At least one orifice 56 is positioned in the bottom zone of the receiver vessel in the bottom surface 54 adjacent to and preferably below the path of the bladed agitator 50 so that rotation of the bladed agitator causes each blade to wipe by the inlet to the orifice, preventing clogging. The orifice 56 is connected through appropriate piping 58 to the atmosphere. A gate valve assembly 60 having a controller 61 is preferably positioned in the orifice 56 for adjusting and closing its aperture, if desired. In the bottom zone, spaced apart from the orifice, there is a pressurized fluid inlet 70 which is connected through valve 74 or 75 to a source of high pressure fluid, for example, high pressure, steam taken, for example, from the top of the pressurized digester chamber, or preferably, to a source of cool liquid, such as dilute liquor or water, from line 76. Inlet 72 when utilized is used for the introduction of cool liquid sufficiently in advance of discharge in order that the downwardly moving wood chips will be more effectively cooled as they advance along receiver vessel 40 from inlet 72 to discharge through orifice 56. Level sensor 53 connected to valves 71 or 73 or controller 61 operates such elements as desired.

The operation of the apparatus is as follows: Wood chips are introduced into pressurized reaction vessel 22, and, by the action of the particle advancing means, are moved upwardly toward the outlet in successive increments as new material is added, while the heated cooking liquor effects its cooking action in the cooking zone 46. Cooked wood chips are thus fed past upper strainer 43, through drainage zone 66 thereabove and, at the upper end of said drainage zone, to conveyance 44. The conveyance 44, extending between the two vessels, removes the drained wood chips from reaction vessel 22 to establish and maintain a predetermined level of the top of the mass of wood chips above strainer 43 defining the liquid level in vessel 22 to in turn define the upper end of the drainage zone, as well as to move them to the receiver vessel 48, dropping them thereinto. The wood chips fall toward the bottom of the receiver vessel, thus building up a zone 49 with an upper level 49*a*, sensed by sensor 53 of drained wood chips conveyed thereto at an unduly high rate during non-uniform operation. The rotating driver 52 whirls the bladed agitator 50, maintaining the wood chips in the bottom zone 51 of the receiver vessel 48 in a mobile homogeneous state and wiping the inlet of the orifice 56. The pressure differential across the orifice, attributable to the steam in the upper zone 47 of the receiver vessel 48 and near atmospheric conditions at the orifice outlet causes wood chips to flow outwardly therethrough. The zone 49 of wood chips interposed between the high temperature steam zone 47 in the upper portion of the receiver vessel and the orifice reduces loss of steam by blow-through (direct flow of steam to the orifice), as well as acting as an effective temperature insulating zone, so that the wood chips in the lower portion of vessel 48, at the lower end of zone 49, may be cooled as desired.

As the level of wood chips builds up in the receiver vessel 48 above zone 49 constantly forcing the wood chips downward, the wood chips may begin to compact and to offer great resistance to the rotation of the bladed agitator 50. When this results, either steam valve 74 or liquid valve 75 or one or both of inlet valves 71, 73 and orifice valve 61 is opened by level sensor 53 and high pressure fluid is admitted through inlet 70 and possibly inlet 72 as well to the bottom zone 51 of the receiver vessel 48. The high pressure fluid at least partially equalizes the pressure across the column of wood chips in zone 49, preventing further packing by the steam thereabove, and, additionally, forces some of the compacted wood chips out of the path of the rotating bladed agitator 50, lightening its load and allowing it to maintain proper speed to insure adequate agitation adjacent the orifice 56. Thus, level sensor 53 operates to control the level 49*a* of the stored treated chips by controlling input of fluid and output of pulp. By the addition of the fluid, the fluidity of the pulp in the bottom zone is increased. By this means, the rotating bladed agitator 50 effectively whittles away at the column of wood chips partially held away by the steam.

According to the invention, it is preferred that the inlet be positioned close to or within a region swept by the agitator blades, preferably in the bottom surface 54 so as to clear material from between the blades of the agitator 50. It is also preferred that the inlet 70 be sufficiently spaced apart from the orifice to prevent direct loss of fluid before mixing with the wood chips has an opportunity to take place. The provision of additional inlet 72 permits more effective heat exchange when a cool liquid is introduced therethrough. It should be appreciated, however, that some of the benefits of this invention can be realized in positioning the inlet in the peripheral casing surrounding the blades of the agitator, or in the portion of the bottom zone of the receiver vessel 48 above the rotating agitator 50. It should likewise be apparent that a wide variety of high pressure, low viscosity fluids will serve to lighten the agitator load.

As a particularly important aspect of the invention, especially insofar as fiber damage is concerned, cool water, either in pure form or in the form of dilute liquor at a temperature of sufficiently less than about 212 degrees F. to cool the wood chips so that their temperature is less than 212 degrees F. after discharge, is particularly desirable in that it functions to prevent "flashing" and resulting fiber damage as well as to aid in dilution in preparation for further treatment. Furthermore, the addition of such cool liquid to provide a cool zone 51 is most effective in preventing heat loss which does occur with the use of steam, and this is uniquely possible because the zone 49 of wood chips in receiver vessel 48 acts as a temperature insulating zone so that a high temperature may be maintained in the upper zone 47 of said vessel and low temperature at the bottom thereof providing temperature stability thereby as well, since the high temperature zone 47 above the low temperature zone 49 prevents mixing by convection. Compressed air similarly avoids heat loss. Steam, however, may be used if loss of fiber strength due to "flashing" is not important.

Referring now to FIG. 3, an ammeter, wattmeter, or the like 90 placed in the power line connected to the preferred electric motor agitator drive is connected so as to deliver a signal to an air pilot valve 92, of a type well known in the art. The ammeter signal is related to the energy being consumed by the motor, which is an indication of the resistance to rotation encountered by the agitator 50, in turn being proportional to the compression

of the wood chips and hence to the fluid pressure necessary to be provided at inlets **70**, **72**. With an increase in the ammeter signal, pilot valve **92** increases the air pressure in valve-actuating lines **94**, which opens the valve **96**. A decrease in the signal similarly decreases the setting of the valve. By so utilizing the system of FIG. 3 in FIG. 1, continual automatic operation of the apparatus is achieved.

All examples herein set forth are merely illustrative of the invention and are not to be interpreted as limiting the scope thereof.

What is claimed is:

1. In continuous pulping apparatus comprising a generally upright pressurized elongated reaction vessel of generally uniform circular cross-sectional area for digesting wood chips, and means for feeding substantially continuously a wood chip-liquid mixture into the lower end of said reaction vessel to maintain a compacted mass of wood chips within an elongated zone in the central and opposite upper end portions thereof and advancing the wood chips upwardly through said zone at a rate substantially independent of the movement of liquid in said vessel to treat said wood chips, that improvement consisting of discharging means for discharging treated wood chips from said pressurized reaction vessel, said discharging means including an upright pressurized pulp receiver vessel having a cross-sectional area less than that of said reaction vessel in a ratio of 10–50 to 1, and in free pressure communication with said reaction vessel, said pulp receiver vessel having a bottom surface with a bladed agitator rotatably mounted closely adjacent to said surface and generally centrally thereof on a central shaft to wipe said surface, said bottom having a discharge orifice through said surface and a fluid inlet through said bottom adjacent to said discharge orifice at a position spaced therefrom, means for rotating said agitator to wipe said surface across its area, valve means for controlling the opening of said orifice, valve means controlling the flow of said pressurized fluid through said inlet, means sensing the upper level of wood chips in said receiver vessel, conveyance means located above said upper level of wood chips for moving drained wood chips from said reaction vessel to said pulp receiver vessel for collection therein of substantially drained, treated wood chips, and means responsive to said level sensing means controlling said valve means for controlling the opening of said discharge to control said upper level of orifice wood chips for continuous discharge of said chips through said orifice while providing a flow of pressurized fluid to aid said discharge.

2. In continuous pulping apparatus as claimed in claim **1** wherein said means responsive to said level sensing means also controls said valve means controlling the flow of pressurized fluid through said inlet.

3. In continuous pulping apparatus having a generally upright pressurized elongated reaction vessel of generally circular cross-sectional area for digesting wood chips, means for feeding substantially continuously a wood chip-liquid mixture into the lower end of said reaction vessel to maintain a compacted mass of wood chips within an elongated zone in the central and opposite upper end portions thereof and advancing the wood chips upwardly through said zone at a rate substantially independent of the movement of liquid in said vessel to treat said wood chips, and level means for establishing and maintaining a level of said liquid adjacent the upper end of said vessel, that improvement consisting of discharging means for discharging treated wood chips from said pressurized reaction vessel, said discharging means including an upright pressurized pulp receiver vessel in free pressure communication with said reaction vessel, said pulp receiver vessel having a bottom surface with a bladed agitator rotatably mounted closely adjacent to said surface and generally centrally thereof on a central shaft to wipe said surface, an electric motor driving said central shaft, means having a discharge orifice positioned in said surface radially outwardly of said central shaft beneath the path of said agitator, and means having a fluid inlet in said surface adjacent to said discharge orifice at a position spaced therefrom, means for introducing steam to said fluid inlet from said reaction vessel above said level means for establishing and maintaining the liquid level therein, valve means for controlling the flow of said steam through said inlet responsive to the power consumed by said electric motor to increase inflow upon increase in power consumption of said motor, and conveyance means located above said means for establishing and maintaining the liquid level for moving drained wood chips from said reaction vessel to said discharge vessel for collection therein of substantially drained, treated wood chips and continuous discharge of said chips through said orifice while providing a controlled flow of steam beneath said agitator to aid said discharge.

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