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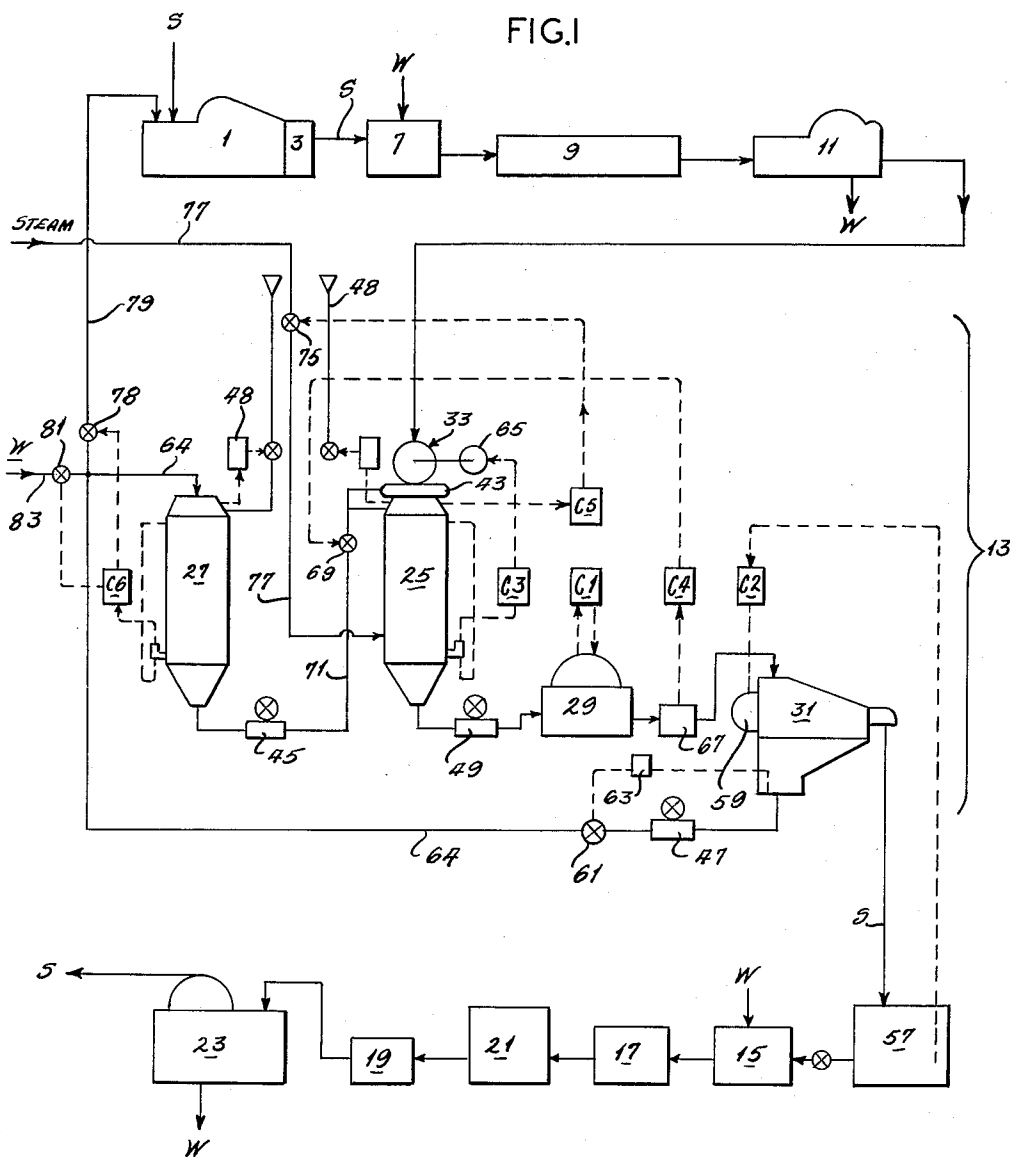
R. F. HOLLIS
DIGESTION OF PULP

2,977,274

Filed July 24, 1957

2 Sheets-Sheet 1

FIG. 1

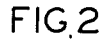


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DIGESTION OF PULP

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2,977,274

DIGESTION OF PULP

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This invention relates generally to the treatment of pulp for manufacture of paper, and more particularly to an improved method of and apparatus for heating and mechanically working wastepaper pulp.

In a typical system for manufacturing paperboard from wastepaper materials, the wastepaper fibers are initially broken down in a breaker beater or pulper and then cleaned so as to remove the solid contaminants which readily separate. The stock is next refined to improve fiber separation and loosen the finer solid contaminants, and perhaps cleaned a second time before being conveyed to the paper fabricating machine. The appearance of the paperboard is not especially good because many of the contaminants in the original wastepaper are not removed but show up as specks or globs on the surface of the board.

Roughly speaking, the contaminants encountered in wastepaper might be classified into a first group which would include such easily removed items as rubber bands, sand, metals, tapes, strings, cork, wood slivers, foils and glass. Non-fibrous materials of this type can be readily eliminated by screens, or centrifugal cleaning units since they are not intimately associated with the fibers.

A second source of contaminants would be inks, pigments and other non-soluble materials which are more intimately associated with the paper fibers. These substances must first be loosened before the pulp can be cleaned, and it is generally recognized that the loosening action of the refining engines is greatly improved if the pulp is heated; i.e., the pulp is mechanically worked under heat and pressure. Accordingly, in those cases where deinking is practiced, it is common to find some atmospheric cooking in the beater or pulper, cooking in pressurized pulpers or perhaps batch cooking in rotary glob digesters. Cooking before refining has the advantage of improving the separation of the fibers but is often accompanied by the disadvantage of degrading the cellulose fibers to an extent such that there is some deterioration in the strength of the paper product. It is believed that fiber degradation is a function of both the degree of temperature and length of time over which the fibers are subjected to it, hence one of the objects of the invention is to provide an improved system wherein the stock is brought up to high temperature, refined and cooled in a short time so as to minimize fiber degradation.

A third type of contaminant would comprise the thermoplastics, such as asphalts, tars and gums, which cannot generally be removed except by pre-selection of the incoming wastepaper. In most deinking plants, these thermoplastic substances are eliminated by using only high-grades of wastepapers, but pre-selection is an expensive process and it is only practiced where the end product is a book, magazine or fine grade of paper that can command a high price. In the manufacture of paperboard, it is desirable, if not essential, from an economical view point to have a minimum amount of pre-selection. Accordingly, the invention does not contemplate elimination of the thermoplastic substances to any great extent,

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but rather it is an object of the invention to disperse these substances by smearing while the pulp is hot, and preferably above atmospheric pressure. Asphalt dispersion has been suggested previously, as in my Patent 2,697,661. The present invention differs from previous asphalt dispersion practices in permitting mechanical working at low stock consistency among other respects.

Another problem is that of conserving heat and chemicals while at the same time providing stock of sufficiently low consistency to permit effective mechanical working at the refining engine. For example, if the asphalt dispersion phase is carried out with a stock at a consistency of say three percent as compared with nine percent, there is three times as much water present, the heat value of which is generally lost when the pulp is cooled as it issues from the refining engines, yet refining engines do not always function efficiently at high stock consistency. These seemingly inconsistent requirements are satisfied in the apparatus and process of this invention by a recycling system utilizing a press for removing the water at high pressure.

While other features of the invention will be apparent from the following description, briefly, a relatively high consistency stock is simultaneously heated and diluted by direct contact with hot water or steam, so as to reduce the consistency to a good level for refining; the pulp is then refined while held under pressure and high temperature and finally is dewatered under pressure and at high temperatures in an enclosed press. The stock issuing from the press at relatively high consistency, for example forty percent, would normally be diluted in relatively cooler water, while the hot water separated at the press may be recycled. In other words, the process is continuous but a recycling effect is achieved affording substantial economies. The diluted stock may be fed direct to the fabricating machine or it may be bleached or further cleaned to remove the fine solid contaminants knocked loose from the fibers by the refining engine, the asphalt or thermoplastics having been effectively dispersed by the press in combination with the disc refiner.

While the invention is particularly directed to a continuous high-efficiency short-cycled thermal system for mechanically working wastepaper pulp, various other features of construction and operation will be apparent. Among these may be noted (1) adaptability to a wide range of pressures (and corresponding temperatures) so as to meet variable cleaning requirements, (2) adaptation to automatic control for simple stabilized operation consistent with the established practices of paper mills, (3) adaptability to use with or without chemicals for improving the cleaning actions, and (4) comparatively low first cost as well as economical operating expense.

Other features of the invention will be in part apparent from and in part pointed out in the following detailed description taken in connection with the accompanying drawings, in which:

Fig. 1 is a diagrammatic flow sheet illustrating a system for manufacturing paperboard from wastepaper and including the thermal stock-working apparatus of this invention;

Fig. 2 is a more detailed diagrammatic representation of certain parts of apparatus illustrating one method of supplying heat; and

Fig. 3 is a detailed diagrammatic representation of part of the apparatus but showing an alternative system for heating the stock.

Prior to the detailed description, it may be helpful to set forth a little background. In making cylinder liners or box board on cylinder machines, there are a number of cylinder vats, each of which builds up a ply of fibers on the felt. The first cylinder may be supplied with a high quality virgin pulp, whereas the following

cylinders may operate with a relatively lower quality pulp, the furnish of which is in part formed from wastepaper. The amount and selection of wastepaper going into the furnish is a matter of cost versus appearance and quality. In other words, it would be desirable to use a large proportion of inexpensive wastepaper in making up the furnish but economy is offset by a significant loss in quality and appearance of the product resulting from the contaminants introduced with the wastepaper. As a result, the trend has been away from the use of so-called mixed wastepapers or those which are likely to present a contaminant problem. In fact, the situation has developed to the point where cylinder liner or filled liner formed with a substantial mixed paper is a drug on the market. Consequently, the basic problem with which this invention is concerned is that of upgrading the quality and appearance of wastepaper pulp, so as to realize their cost advantages over boards formed with a high percentage of virgin pulp and to conserve timber resources.

Deinking of wastepaper has been proposed and has been carried out to some extent, but the emphasis has been on careful selection of the wastepaper materials so as to eliminate contaminants and upon making fine grades of paper which command a high price that will justify the expense of sorting. In contrast, the approach herein is that of admitting the contaminants usually associated with wastepaper and then treating the stock so as to minimize their adverse effects.

In the typical paper mill, about eighty-five percent of the fibers are separated at the initial beater of pulper, usually with the aid of some heat and chemicals, but the temperature is below 212° F. (atmospheric pressure). The other fifteen percent is then broken down in refining machines such as jordans or disc refiners. It is not unusual to follow the refining with some cleaning, but this cleaning operation still leaves the pulp in a comparatively dirty condition, as compared with virgin pulp. Accordingly, the invention is directed to a system for more effectively loosening the finer solid contaminants associated with the fibers which have not heretofore been removed. Also, the invention contemplates dispersion of the asphalts and other thermoplastic materials.

While digesting of wastepaper pulp is practiced in some present deinking processes, the cooking step usually is in conjunction with the initial pulping at low temperature or is a batch process operation in rotary digesters. Necessarily, a continuous process is much preferred and really effective dispersion of contaminants requires mechanical working at temperatures on the order of 250° F. or above, which means a pressurized system.

In connection with cooking, it may be noted that high temperature has a degrading effect on the cellulose fibers and sometimes discolors them. This problem is met in the disclosed system by a relatively short dwell time in the high temperature phase of the system. In other words, the stock is brought up to the necessary temperature, refined and squeezed to smear the asphalt, all in a relatively short time, thereby minimizing the fiber degrading effects of high temperatures. Moreover, the refining action during the high temperature phase is carried out at low consistency so as to achieve a maximum effect in loosening contaminants as well as in smearing the asphalt. While various operating conditions will be disclosed in detail, it should be understood, that they may vary over relatively wide ranges depending upon the extent of contamination and the desired results.

Referring now to Fig. 1, the papermaking process typically begins at a breaker-beater or pulper 1. The incoming fibrous materials, including wastepaper, are dumped into the beater or pulper 1 and milled with white water to break down the paper into a pulp. The

stock S may be drawn off through a regulating box 3 to a diluting tank 7. Customarily, the consistency of the stock is reduced to a level of one percent or less prior to being fed to a mechanical cleaning unit 9, which removes such heavier non-soluble items as rubber bands, tapes, strings, sand, metals and glass. The details of the mechanical cleaning, which may include screens and centrifugal cleaners, will be understood to those skilled in the art, hence is not further described. The necessity for such mechanical cleaning necessarily depends upon the character of the incoming wastepaper, but is generally preferred over pre-selection where the wastepapers are sorted and likely contaminants pitched out manually.

After mechanical cleaning, the stock S is dewatered at 11 so as to increase the consistency before being conveyed to the thermal unit 13 of this invention. It may be noted that the thermal efficiency of the unit 13 is improved with higher stock consistency, and the unit is adapted to operate over a wide range of input consistencies. Dewatering may be accomplished by various machines well known to those skilled in the art, the selection of which depends upon the desired consistency of the stock feed to the thermal unit. For example, a vacuum decker may be used to elevate the consistency to about sixteen percent and a press used where higher consistency input to the thermal unit is desired.

The output from the thermal unit 13 is then piped to a diluter 15, the function of which is to reduce the consistency to a level for more effective secondary cleaning at 17 and secondary refining at 19, if desired. Secondary cleaning or deinking removes the solid contaminants which were not removed in the primary cleaning but which were loosened from the fibers in the thermal unit. The pulp can be bleached and washed at 21 before being fed to the fabricating machine 23, but it will be understood that the secondary cleaning, refining and bleaching are optional. Indeed, the thermal unit of the invention might be incorporated at any point between the initial pulping and the final fabrication. Secondary cleaning may be by a "hill-side" screen, flotation apparatus or centrifugal cyclones. While much of the water W drawn off at various points in the system may be reused, some of the affluent which contains contaminants might be discharged to the sewer.

Referring now to Figs. 1 and 2, the thermal apparatus 13 basically comprises a stock receiver 25, a water receiver 27, a refining engine 29 and a press 31. The pulp is brought up to temperature in the stock receiver 25, which is arranged to provide for a relatively short dwell in the system, then refined as by a disc refiner which is constructed to withstand substantial inlet and outlet pressure, and finally squeezed as by a screw press, which is also constructed to withstand substantial pressure. The water outlet or discharge from the press is sealed and adapted to withstand pressure, and the hot water therefrom is fed back to the water receiver 27, which functions as a reservoir supplying the stock receiver. In other words, the entire system is pressurized so as to conserve heat or energy. The heat input for the stock may be indirect by heating at the water reservoir 27 or by direct application of steam into the stock receiver 25.

More particularly, the stock receiver is a vertical tank having an outlet at the bottom and a pressure-containing input unit 33 at the top. Preferably, a motorized star valve is used at the input, such valve being known in the art, for example, a Bauer-Gremco model of twelve inches by twenty-four inches size rated at 150 p.s.i.g. steam working pressure. The valve includes a housing 35 containing a rotor 37, which is formed with a plurality of peripherally-spaced pockets 39. The incoming stock is forced into a top pocket at relatively low pressure and is subsequently dumped as the pocket moves around to the bottom position. It is contemplated that a small steam nozzle will be arranged to squirt a small jet of hot water

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into the lower pocket, as at 40, to insure complete dump of the stock at the bottom position. On dense stock, the valve is generally rated at 1.50 cubic feet as compared with the 2.0 cubic feet actual volume. Thinner stocks would fill the pockets. The speed may be as high as 24 r.p.m., but it is contemplated that a variable speed drive will be provided for the rotor in order to permit controlled variation in the input to the system.

The stock receiving tank is only partially filled with hot water so that the pocket-sized gobs of stock discharged from the valve drop through a gas phase before entering the liquid. The gobs of stock are preferably broken up as they drop by a plurality of nozzles 41 arranged peripherally about the tank immediately below the valve and above the liquid level. The nozzles 41 are connected to a ring-type manifold 43, as shown, which is supplied with hot water, although steam might be satisfactory in some instances. Also, the nozzles 41 are preferably arranged to apply a slight whirling jet effect to the stock in the downward direction so as to aid in non-condensable gas release. A pump 45 connected in the supply line to the manifold provides the spray head or energy.

The pump 45 and associated supply line are connected to the bottom of the water return tank 27. The return water is pumped at 47 from the press to the top of the return water receiver 27. Non-condensable gas venting devices 49 are provided on each tank, as shown.

The heat input to the system may be in varying manners, two main types of which may be mentioned. Fig. 3 shows a system involving indirect heating at the water receiver 27 by circulating water from the tank 27 through a tubular hot water heater 28. This type of heating has certain advantages, among which may be mentioned no danger of burning stock with super heated steam and certain economic values from condensate return to the boiler room. The main disadvantage is that the thermal head on the water receiver, in terms of pressure and temperature, must lead that on the stock receiver, because all the new heat energy must come via the enthalpy of the liquid in the line served by pump 45. This gives us a high "false" thermal head under conditions of low stock input density and high stock receiver temperatures.

The other type of heating, which is shown in Figs. 1 and 2, is by direct injection of steam at 30 into the stock receiver 25. Condensate return is not possible since it goes into the process water and slightly builds up the bleed from the system to the beater or pulper. The main advantage is that the thermal head required is net, and no false high limitations show up, because the heat energy goes directly into the stock, the latent enthalpy being released by direct condensation of the steam. With densities of stock of three to six percent, normally experienced super heat from turbine exhaust or extraction will not burn the stock in the nozzle zone. Only direct expansion via reducing valves of high-pressure superheated boiler steam should cause difficulty in this respect.

The output from the stock receiver 25 is pumped at 49 into a refining engine, which has the function of breaking up the small fiber units which have not otherwise separated, loosening solid non-soluble contaminants so that they may be removed subsequently and to some extent smearing the non-soluble thermoplastic constituents such as asphalt. A pump-through disc type refiner, such as Bauer No. 440, is contemplated for the unit 29. The pump 49 associated therewith may not be necessary, however, since the refiner has some pump-through action of its own. In any case, the pump 49 will overcome any pressure drop in the refiner, hence may be thought of as a booster. Such refining engines may have a limitation in that they do not operate too efficiently, at least from the viewpoint of loosening fibers and finer contaminants, when the stock consistency is relatively high, say above seven percent.

The disc refiner typically has a pair of disc-like plates

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50, at least one of which is rotated by a motor M1. The incoming stock is fed axially between the plates and in flowing outwardly undergoes a severe rubbing action. A control C1 may be employed to vary the space between the plates and thereby the flow of material there-through. Of course, a close spacing provides more working and relatively lower flow. Ideally, the control C1 will be set up to provide a constant energy input, either in terms of horsepower or kilowatt-hours per ton for variable stock flow. It should be understood, however, that the disc refiner 29 differs from the more conventional in that it includes a pressurized output system so as to contain the pressurized stock as it is fed to the press 31.

The press may be a Sutherland No. 4 heavy duty unit, which is modified to include a pressurized sump 55 for the squeeze-out water. Such presses are commonly made with a screw 51 which is contained within a screen-like screw housing 53 so that the water is squeezed through the screen as the stock is moved by the screw toward the output end. The press 31 not only dewateres the stock but has a function which is important to this application, and that is asphalt or thermoplastic dispression. In other words, pressures as high as eight thousand p.s.i.g. may be developed locally within the press, and since the stock is maintained at elevated temperatures in the press, there is a pronounced and effective asphalt dispersion action.

The screen 53 might have one-eighth inch holes, hence some of the fibers may come out with the water, although this will generally not be enough to worry about. Also, some of the soluble contaminants will be squeezed out with the water, but it is believed that the amount removed will not be enough to justify a special treating process or introduce complications in the recirculation thereof.

The press 31 discharges the high-consistency stock into a chest 57, from which the stock is drawn for further processing. Automatic control is then obtained by providing a controller C2, which is arranged to sense variations of the level within the chest 57 and adjust a variable speed drive 59 for the press accordingly. In other words, when the level in chest 57 drops as a result of a change in the rate of draw off, the speed of the press is changed to increase the discharge. Since the amount of water extracted by the press will vary with its speed, a controller 63 is provided to modulate a valve 61 beyond the pump 47, thereby controlling the flow through the line 64 to the water-storage vessel 27. The pumps are necessarily of an open-impeller type.

As the press speeds up, there is an increasing flow of stock through the disc refiner 29 which tends to draw down the level within the stock-receiving vessel 25. Both the pump 49 and disc refiner 29 are boosters so that they do not inhibit the flow of stock to the press. A level controller C3 is associated with the vessel 25 and is connected to control a variable-speed drive 65, which rotates the star valve 33. Consequently, a variation in the flow from the tank 25 is compensated for by a corresponding change in the flow into the vessel at 33, thereby tending to hold the liquid level at a predetermined value.

A further controller C4 is provided to regulate the consistency of the stock leaving the vessel 25. A device 67 responsive to the stock consistency is interposed in the stock line leaving the refiner 29 and is connected to the controller C4, and the controller in turn is connected to modulate a valve 69 in the water supply line 71 leading from the water tank 27 to the water injection nozzles of the vessel 25. Accordingly, both the rate of flow through the system and the consistency of the stock are controlled automatically, the consistency being held to a predetermined level selected on the controller C4 in order to achieve most efficient refining conditions. The temperature of the stock is regulated by a controller C5, which may have a pressure or temperature responsive element 73 in the top of the stock vessel 25 and which is connected to a valve 75 in the steam supply line 77.

Finally, the flow into the water storage tank is regulated

in accordance with the output. A level controller C6 is associated with this storage tank and modulates a valve 78 to control bleed off through a line 79. The bleed off line may feed to the initial pulper 1 so as to conserve the heat and chemicals. The controller C6 may also operate a second valve 81 in a water input line 83, although the valve 81 would be opened only during start up of the system. The various control units are items which are known in the trade, hence are not described in detail.

In operation, the start up sequence might involve first filling the system with water until the controllers C3 and C6 have taken over control to maintain predetermined levels in the two vertical vessels 25 and 27. The disc of the refiner 29 would be in its "out" position when it is then started and the press would recirculate all water. The controller C5 operates the steam valve 75 to bring the temperature up to the desired predetermined value, which is set on the controller C5. The disc refiner may then be started along with the star valve 33 so that stock begins to feed into the system. As the stock consistency builds up, the controller C4 will assume control over the flow of water into the stock vessel 25 and maintain any desired consistency. Although not shown in this system, the controller C3 can be provided with impulse valves for shutting down the system in the event of malfunctioning. In other words, a rise or drop of the level in the stock tank beyond normal limits will result in a shut off sequence of operations. The shut off sequence would take water control away from the consistency controller C4, stop the star valve 33, back off the rotor disc of the refiner 29 and speed up the press 31 to purge the system of stock.

The system is adapted to operate over a relatively wide range of conditions. For example, under one condition of operation, the stock input at the star valve might be at the rate of 150 tons per day of 10 percent consistency stock (249 gallons of water per minute). The steam demand would be about 1300 pounds per hour at 15 p.s.i. (26 gallons per minute) from a turbo-extractor. The flow of recycled hot water into the stock vessel would be 374 gallons per minute at 228° F. or 10 p.s.i. The diluted stock passing through the refiner 29 would be at a rate of 150 tons per day at 4 percent consistency or (623 gallons per minute at 228° F.) The press could then produce 150 tons per day at 30 percent consistency and 228° F. (89 gallons per minute) and the extracted water flow through the pump 47 would be 534 gallons per minute at 228° F. It will be noted the extracted water exceeds the amount required by the stock vessel, hence the valve 78 will be modulated to bleed off 160 gallons per minute, leaving 374 gallons per minute feed to the storage tank 27.

Under another condition of operation, the input through the star valve might be 200 tons per day at 40 percent consistency (82 gallons of water per minute), in which event, the flow of diluted water into the stock vessel would be 748 gallons per minute to maintain an output of 200 tons per day at 4 percent consistency (830 gallons per minute). The press might then be operated to produce 200 tons per day of stock at 40 percent consistency (82 gallons of water per minute) and the extracted water being at a rate of 748 gallons per minute, all being fed to the storage tank 27.

With this example, the stock in vessel 25 might be at 265° F. and 30 p.s.i., these temperature and pressure conditions being substantially the same throughout the system. Steam input by direct injection into the stock receiver would be 6358 p.p.h. at 40 p.s.i.

The dwell from the time the stock drops into the vessel 25 and its discharge from the press 31 can be predetermined by the size of the vessel 25, a large diameter tank affording a relatively longer stock heating cycle.

In other words, the stock heating cycle can be controlled independently of the speed at which the stock is pumped through the system. A suggested cycle would be about three minutes, but it should be understood this time can be varied in accordance with the temperature conditions and the type of stock. In general, however, this is a quick-cycle thermal system because the stock is brought up to the desired temperature almost instantaneously upon entering the stock-receiving vessel, as contrasted with a system where the temperature of relatively low-consistency stock is gradually elevated in a heat exchanger. For this reason, the diameter of the vertical stock-receiving vessel may be substantially larger than that of the pipes leading to and from the vessel.

The maximum thermal efficiency is achieved when the consistency of stock entering the vessel 25 approaches that of the stock discharged from the press 31, but this is not essential. In fact, there might be no dilution in the stock vessel other than that by injected steam, and some heat conservation would still be possible by recycling the press-extracted water to the pulper or another preceding unit in the overall system. On the other hand, the system preferably contemplates the use of a water storage tank and recycling of a substantial part of the extracted hot water into the stock-receiving vessel, i.e., a substantial recycling effect in the thermal portion of the system itself. Since the thermal system is entirely pressurized, there is substantially greater heat conservation when the water is maintained under pressure and not released to atmospheric pressure. While several examples have been disclosed, it is to be understood that various individual features of this system might be modified or even eliminated without departing from the spirit of the invention or the scope thereof, as set forth in the appended claims.

Having thus described the invention, what is claimed and desired to be secured by Letters Patent is:

1. In the art of making paper from waste papers which contain thermoplastic contaminants, the process which comprises the steps of continuously diluting and heating stock by feeding it into a vessel containing liquid maintained under pressure and at temperatures above 100° C., thereby quickly to elevate the temperature and dilute the incoming stock, withdrawing said stock from said vessel at a rapid rate so that it does not remain in the vessel over a prolonged period of time, and then squeezing the hot diluted stock in a rotary screw press, thereby smearing the softened thermoplastic contaminants as the water is extracted.

2. The process set forth in claim 1, which further comprises the steps of conveying said stock through a disc refiner while in its hot diluted condition after leaving the vessel and before entering the press.

3. The process set forth in claim 1, which further comprises the step of maintaining the extracted hot water under pressure and at a temperature greater than 100° C. and recycling the extracted water to said vessel for heating and diluting more stock.

4. The process set forth in claim 1, wherein hot water is metered into said vessel at a rate sufficient to maintain a predetermined level therein.

5. The process set forth in claim 4, wherein said stock enters through the top of the vessel so as to pass through a gaseous phase upon entering the vessel.

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