

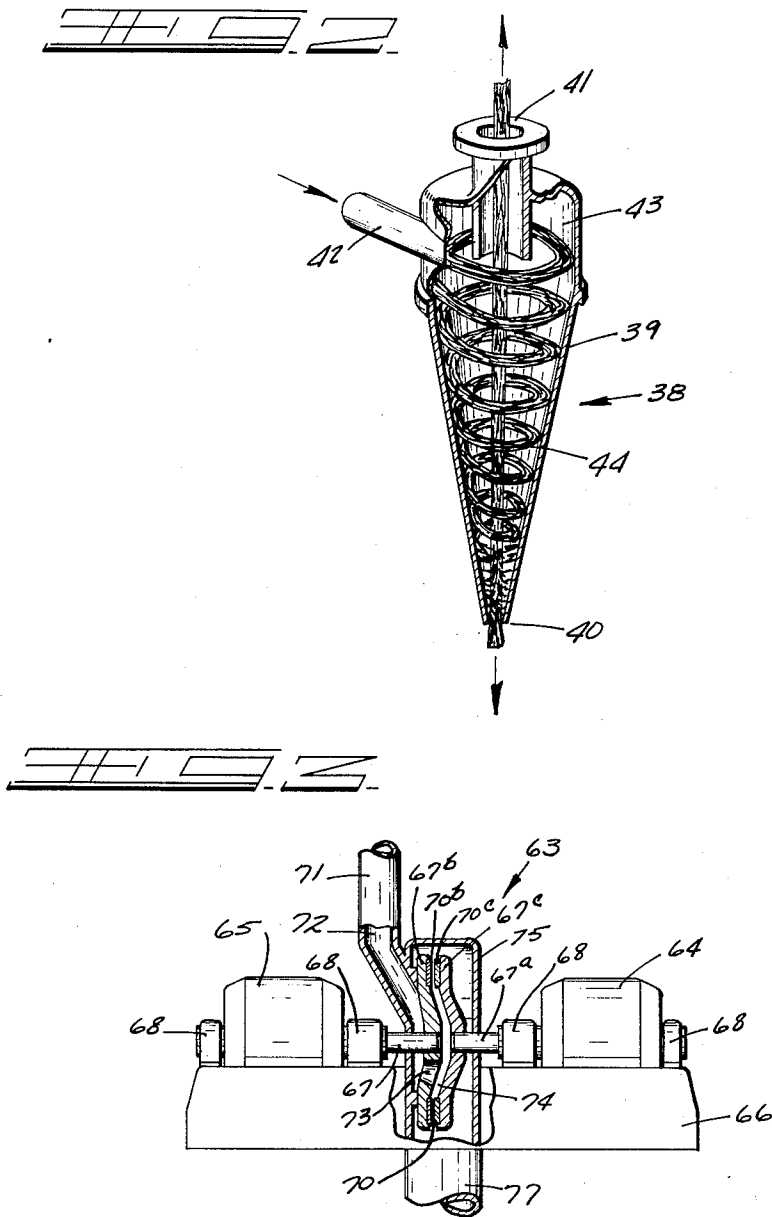
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MANUFACTURE OF PAPER

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MANUFACTURE OF PAPER

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The present invention relates to the manufacture of paper, and, more particularly, to the manufacture of paper from wood or timber. Even more particularly, the present invention relates to a process for handling pulp stock after it has been washed, and prior to its being deposited on the paper machine.

In the manufacture of paper from wood, the wood is first reduced to chip size, then exposed to either chemical, semi-chemical, or mechanical degradation to separate the fibers from the bonding agents and other constituents of the natural tree. Subsequent to this, the fibers, in combination with the liquor or an aqueous suspension, are subjected to a series of physical refining and defibrating operations which serve to fillibrate or fluff the fibers into a form wherein they are hydrophylic. Subsequent to this, and more commonly in the chemical processes, the pulp is washed to leach out the chemical values and to separate and clean the pulp from the chemical constituents of the liquor, as well as from other undesirable ingredients. Customarily, the pulp is then processed through various additional refining and diluted with water, whereupon it is deposited on the wire of a paper machine for the production of the sheet. Examination of the pulp proceeding from the washing step reveals it to normally contain bark particles, knots, shives, and the like, which exist in the form of rather dense particles which prove to be deleterious in the forming and drying of the sheet, and are further a cause of weakness in the final formed sheet. In particular, it is found that these particles hold the sheet away from the drying rolls, and thus reduce the amount of heat transfer, whereby it is necessary to employ additional drying rolls to achieve a desired state of dryness. In addition, when the sheet is formed, routine crush tests performed thereon reveal that the sheet is not as strong as would be desirable. This undesirable phenomena is particularly evidenced in the manufacture of corrugating medium, wherein crush strength is a property of paramount importance.

It has been proposed heretofore that it would be desirable to remove these bark particles, shives, knots, and the like, by various separation schemes. Conventionally, in such schemes, the separated particles are completely removed and directed to waste. Unfortunately, in some of these separation processes, it is found that a proportion of paper-forming fibers are removed, which reduces the overall yield of the paper manufacturing process. Furthermore, the separated particles, upon close examination, are found to be composed of a fair proportion of paper-forming fibers, but such are so highly densified that it has not been thought possible heretofore to efficiently convert them into an undensified fibrous form adaptable to forming a sheet.

Accordingly, it is an object of the present invention to provide a method for treating semi-chemical pulp stock which will convert undesirable bark particles, shives, knots, and the like into useful form for production of paper.

It is an additional object of the present invention to provide such a method which may be continuously carried out by routing the paper stock through a preselected series of steps harmonious with established paper manufacturing techniques.

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It is still another object of the present invention to provide a process which exposes pulp stock to a series of sequence of weight fractionation zones, the lighter weight fractions being advanced in reverse direction to the heavier weight fractions, while the final heavier weight fraction from the last zone is vigorously refined and then reintroduced into the pulp stock stream.

It is an additional object of the present invention to provide such a process which does not require any provision for waste or ponding of undesirable bark particles, shives, knots and impurities from pulp stock.

The above objects, as well as other objects of the invention, will become apparent to those skilled in the art from the following detailed description, taken in conjunction with the attached sheets of drawings, on which there are presented for purposes of illustration only, a preferred embodiment and mode of practicing the method of the invention.

In the drawings:

FIG. 1 is a partially diagrammatic and partially schematic flow diagram showing the flow of pulp stock liquid in accordance with the method of the invention.

FIG. 2 is a schematic view, with portions partially broken away, showing one of the zones for effecting a stock separation in accordance with one step of the invention.

FIG. 3 is an elevational view of a refining mechanism, portions thereof being broken away to show the interior construction.

In its simplest embodiment, the present invention includes successive separations of substantially impurity-free pulp from impurity-containing pulp, the impurity-free pulp from successive stages being directed to the preceding step, the impurity-containing pulp from the last stage being exposed to a mechanical shear to reduce the remaining particles to a size or form which is compatible with paper-forming stock, while the substantially impurity-free pulp is continuously directed to the paper machine.

Referring now more specifically to the drawings, there is shown in FIG. 1 in diagrammatic form, a flow diagram illustrating the principal steps and processes involved in the manufacture of paper, and including the improvements of the present invention. Logs of wood are introduced into a chipper 11 where the logs are reduced to small chips of about $\frac{3}{4}$ " size. The chips are then passed into a digester concurrently with a supply of steam, and, in the chemical and semi-chemical processes, a quantity of so-called liquor containing digesting chemicals. The digester is usually maintained under steam pressure, and, after sufficient residence time, in which the chemical content of the liquor attacks the binding agents, the digested pulp is passed in turn through a defibrator 15 and a Sutherland refiner 16 which exerts a mechanical shearing action on the fibers of any remaining chips. From the refiner, the chips and liquor pass to a series of drum washers 18, which are also supplied with fresh wash water. The drums have a reticulated, perforated, or screen-like surface, and a vacuum is maintained within for drawing liquid from the pulp which is left on the outer reticulated surfaces of the drums. The liquor drawn into the drums is then passed to a chemical recovery unit 20. The chemical recovery unit includes several operations such as evaporation to concentrate the residual chemicals, ignition to separate undesirable combustible complexes, forming a solution of smelt, absorption of make-up chemicals, and clarification. These are well known operations and form no part of the present invention, so they need not be discussed in detail. At any rate, the recovered chemicals are then reintroduced into the digester 13 as fresh liquor.

The pulp is at the same time passed from the washers

to a platform chest 21 which serves as a hold tank. At this stage, the pulp is rather free and dark in color. This free pulp is pumped by a centrifugal pump 22 to a plurality of Jordan refiners 24 for additional physical work on the pulp. From the Jordans, the pulp passes to a pair of machine chests 26 (machine chest #1) and 27 (machine chest #2). For simplicity of illustration, the process description will be confined to the flow from just one machine chest, as both are the same. The amount of pulp stock produced from the wood as described to this point may be supplemented by the addition of some waste paper pulp which is also introduced to the machine chest, as shown. From the machine chest, the pulp stock is pumped by pump 28 to another series of Jordans 29 for further refining of the pulp stock. From these latter Jordans, referred to commonly as "tickler" Jordans, pulp stock is introduced into a stuff box 30. The stuff box is provided with vertical baffle plates 31 and 32 to divide the stuff box into compartments 33, 34, and 35. The stock is piped in at the bottom into the center compartment 34, and is constantly mixed by mixer 34a. The pulp stock introduced into the center compartment 34 flows up and over the baffle plates into compartments 33 or 35. The pulp stock flowing into compartment 33 is drawn off and recirculated to the machine chest 26, while the stock which flows into compartment 35 passes on for treatment in accordance with the invention. Consistency of the stock is regulated in the manner described on pages 528 and 529 of the third edition of Calkin and Witham text, "Modern Pulp and Paper-Making." In brief, this system described amounts to a De Zurik type utilizing the torque necessary to turn the mixer to regulate delivery of a predetermined amount of dilution water to give the desired consistency, in this case 4%. By the term "consistency" is meant the relative proportion of pulp and water. Thus, pulp stock having a consistency of 4% designates that in 100 parts of the pulp stock, four parts by weight are oven-dried cellulose fibers, and 96 parts by weight are water. From the stuff box, the pulp passes to a series of separation stages identified as Processing Stage A, Stage B, and Stage C. Each stage includes a plurality of conical tanks fluidly connected together in parallel relationship with the tanks in that stage; however, for simplicity of illustration, each stage is represented in the drawings as constituting single tanks 38a, 38b, and 38c, respectively.

The individual tanks are identical and are constructed as illustrated in FIG. 2, wherein the tank 38 is shown as consisting of a conical-shaped shell 39, a portion of which is broken away to show the hollow interior. The conical shell 39 has a lower outlet 40 and a somewhat larger upper outlet 41, both openings being axially located on the axis of the conical shell. A horizontal pipe 42 serves as an inlet to the tank, and it is in tangential relationship at the upper end of larger sectional area, so that stock introduced therethrough passes into contact with the curved inner surface 43 of the tank. As the stock enters the tank, gravity causes it to fall downward, while, at the same time, the curved inner surface causes the inlet supply to travel in spiral fashion as represented schematically by the flow lines identified by reference numeral 44. This flow may be described as a vortical flow, and is effective to cause the stock fraction of higher apparent specific gravity (by reason of the high proportion of high density particles, etc.) to tend to travel proximate the inner surface, while causing the lighter weight fraction of substantially impurity-free stock to congregate inwardly therefrom proximate the axis of the conical tank. As a result of the above conditions, there is achieved what may be referred to as a weight fractionation of the supplied stock liquid in that stock issuing from outlet 40 at the bottom tends to have a higher concentration of impurities (higher specific gravity), while that issuing from upper outlet 41 is lighter by reason of its being freer of impurities.

Referring now back to FIG. 1, the stock passes from the stuff box through line 36 to pump 37, and then through inlet 42a into tank 38a, constituting the first stage. The vortical flow within tank 38a, as described above, causes a weight fractionation so that lighter weight stock (substantially free of impurities) passes out outlet 41a to the head box 46 via line 46a and thence is deposited onto the wire 47 of a paper machine 48. The heavier fraction of stock (higher in impurities than that passing out the upper outlet) passes down and out outlet 40 into line 50 which leads to tank 51 which is maintained under a vacuum of about 14" to 16" Hg. From tank 51, the stock is pumped by pump 52 via line 53 to inlet 42b of the conical tank 38b of the second stage, wherein is maintained a condition of vortical flow, as described hereinabove in connection with tank 38. The lighter weight stock fraction issuing from outlet 41b passes via line 53 back into line 36 for reintroduction into tank 38a of the first stage. The heavier weight fraction stock containing a higher proportion of impurities is passed out outlet 40b via line 55 into tank 56, from which it is pumped via pump 58 into conical tank 38c of the third stage. The lighter weight fraction stock issuing from upper outlet 41c of the third stage tank is passed via line 57 to a mixing box 59 which is also supplied with a quantity of dilution water. The heavier weight fraction stock leaving lower outlet 40c of the third stage falls into a screw conveyor 61 which delivers this stock possessing the highest proportions of particles, impurities, and the like into a refiner 63, driven by motors 64 and 65.

The refiner 63 is shown in greater detail in FIG. 3. It is mounted on a table support 66 and is composed of a pair of aligned shafts 67 and 67a journaled in mountings 68 having therebetween a drive motor 65 for shaft 67 and a drive motor 64 for shaft 67a. Mounted on the ends of each of the shafts 67 and 67a are plates or disks 67b and 67c which rotate with the shafts in opposite directions. The peripheral facing surfaces of the disks are provided with annular metal inserts 70b and 70c, respectively. The inserts are of jagged contour so as to exert shear in the space between them. The stock is introduced through pipe 71 which defines a passageway 72 leading to the shaft disk connection portion from which it may pass through passageways 73 in the disk 67b and into space 74 between the disks. The rotation of the disks causes the stock to pass radially outward between the inserts, where the shearing forces cause the stock or particles in the stock to be reduced in size. The reduced stock is thrown radially outward and impinges on a housing 75, from which it falls downwardly through outlet 77.

Referring now back to FIG. 1, the stock leaving the refiner 63 passes into a tank 80, from which it is pumped via pump 81 through line 82 back to the platform chest (hold tank) 21 where it is merged with pulp stock coming from the pulp washers for recirculation in the improved processing scheme of this invention.

In introducing stock to the various stages, it is desired that the percent consistency be quite dilute. Accordingly dilution water is added to the stock just prior to the introduction thereof into the various tanks of the three stages. The dilution water is obtained from the mixing box 59 which receives all the light-weight stock from the upper outlet of the third stage tank and other dilution water as, for instance, from the Fourdrinier machine. The flow from the mixing tank to the various stages is as follows: The mixing box stock passes out line 90, which, in turn, connects with line 91 leading to the suction side of pump 37 for the primary stage tank 38a. When the actual mill is operated in accordance with the above description, it has been found that first the flows, particularly from the machine chest to the paper machine, are allowed to come to an equilibrium condition. Then, appropriate adjustments of flow rates can be made to put the right consistency pulp on the wire. This will vary, depending upon the type of paper, the efficiency of the

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paper machine, the sizing, and many other factors. For the mill concerned here, a semi-chemical corrugating medium pulp mill, the consistency of the pulp stock should be very close to 1.2%. With this established, the flows in the various stages are adjusted to give the best operating conditions for production of the pulp and reintroduction of the normally ponded higher weight fraction from the third stage into the pulp stock steam, e.g., at the platform chest.

In Table I, there is listed in tabular form a typical set of conditions in the three stages of the separation system.

TABLE I

	Inlet ¹		Upper Outlet ²		Lower Outlet ³	
	Flow Rate, Gal./Min.	Consistency, Percent	Flow Rate, Gal./Min.	Consistency, Percent	Flow Rate, Gal./Min.	Consistency, Percent
Stage A (Tank 38a)-----	2,020	1.5	1,800	1.2	220	5.3
Stage B (Tank 38b)-----	820	1.43	730	0.77	90	6.5
Stage C (Tank 38c)-----	450	1.36	400	0.57	50	7.7

¹ Identified in the drawings by reference numeral 42.

² Identified in the drawings by reference numeral 41.

³ Identified in the drawings by reference numeral 40.

These conditions of flow rate and stock consistency are desirably maintained in order to achieve the optimum separation of the heavier fraction of stock which, as explained hereinabove, contains a high proportion of the impurities in the way of bark particles, shives, and knots.

Reading horizontally in the table, it can be seen that stock entering Stage A flows at 2020 gallons per minute and is then separated into a light fraction (1.2% consistency) and a heavier fraction (5.3% consistency), the flow rates thereof together equaling the inlet flow rate. The fraction leaving Stage A from the upper outlet goes to the head box and onto the paper machine, while the fraction leaving via the lower outlet goes to the second stage. The 220 rate is supplemented by dilution water to bring the consistency of 5.3% down to 1.43%, and, accordingly, ups the flow rate to 820 gallons per minute which is the rate of flow introduced into the inlet of the second stage. Reading horizontally again, it can be seen that the stock introduced to Stage B is separated into a light fraction (0.77 consistency) and a heavier fraction (6.5% consistency). The light fraction leaving the upper outlet goes back to be reintroduced into the first stage, while the heavier fraction leaving via the lower outlet goes to the third Stage C. This fraction leaving the lower outlet of the second stage at 90 gallons per minute is diluted to lower the consistency from 6.5% to 1.36%. This, of course, increases the flow rate to 450 gallons per minute, and such is introduced to the third stage. Again reading horizontally, the stock liquid introduced is separated into a lighter fraction (0.57 consistency) and a heavier fraction (7.7% consistency). The lighter fraction is pumped to the mixing box 59, where it is mixed with dilution water (any process water from the wire section of the machine may be used), and then pumped to any of the three stages, as needed, to provide dilution as described hereinabove.

Example I

A stock flow system as hereinabove described has been operated in a pulp mill producing two hundred (200) tons of pulp per day, this figure representing the amount of pulp (on an oven-dry basis) which is laid down on the wire of the machine. One hundred seventy (170) tons of the pulp is derived from the digestion of wood, while thirty (30) tons constitute a supplemental amount of pulp from waste paper as shown being introduced into the machine chest 26. Using the process of the invention, it is found that about thirty (30) tons per day of refined

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pulp issuing from the third stage tank 38c through the refiner 63 is reintroduced back to the platform chest, making a total of two hundred (200) tons of pulp a day leaving the platform chest. This, plus the thirty (30) tons of waste pulp introduced at the machine chest, makes two hundred thirty (230) tons of pulp per day being introduced into the stuffing box, and two hundred thirty (230) tons per day likewise introduced into the first stage tank or primary tank 38. Considering the tanks 38a, 38b, and 38c as connected in series, inasmuch as the flows are connected, it is found that the first tank passes on as acceptable stock to the paper machine two hundred tons a day, while there is separated about thirty (30) tons a day which is refined in the double disk refiner as described above, and this thirty (30) tons per day of refined stock reintroduced into the platform chest. The stock liquids introduced into the three stages are preferably pumped under a pressure of 40 to 50 p.s.i. gauge, in order to obtain the highest efficiency separation of the higher and lower weight fractions, although pressure less than this can be used.

Modifications may be resorted to without departing from the spirit and scope of the invention as defined in the appended claims.

We claim:

1. A method of processing pulp formed from wood, said pulp characterized by a content of undesirable impurities in the form of wood-bark particles, shives, knots, and the like, which comprises washing said pulp, diluting said pulp stock with water to a consistency ranging from about 0.8 to 1.8% pulp, introducing said diluted stock into a zone of vortical flow, thereby effecting vortical hydraulic separation of a fraction low in impurities content from a fraction higher in impurities content due to the combined effects of gravitational, rotational, and hydraulic forces, introducing said fraction of higher impurity content into a second zone of vortical flow, thereby forming a second set of fractions of high and low impurity content, returning said last-mentioned fraction to said first zone, directing said other high impurity fraction to a third zone of vortical flow, thereby effecting a third pair of fractions of high and low impurity content, returning the last-mentioned fraction to said first zone, subjecting said last-mentioned high impurity content fraction to a mechanical refining to reduce the size of said impurities, and reintroducing said refined fraction to said diluted pulp stock, said fraction from said first zone, which is low in impurities content, being continuously removed from said first zone and directed to the paper machine.

2. A method of processing pulp stock containing impurities in the form of bark particles, knots, shives, and the like, which method comprises diluting said stock with water to a consistency ranging from about 0.8 to 1.8% pulp, pumping said diluted stock under pressure and tangentially into a zone characterized by vortical flow, wherein undesirable particles and some pulp stock gravitate to the bottom of said flow and acceptable stock floats to the top of said flow due to the combined effects of gravitational, rotational and hydraulic forces, collecting acceptable stock for transfer to paper-forming operations, collecting said pulp stock fraction containing undesirable particles, diluting said fraction, pumping said just diluted fraction to a second zone of vortical flow, wherein vortical separation occurs as described in the first of said zones, collecting acceptable stock and cycling same to said first zone, removing said pulp stock fraction containing undesirable particles, diluting said collection fraction, pumping said diluted fraction to a third zone, collecting acceptable stock and directing it to said first zone, collecting said pulp stock fraction containing undesirable particles and exposing said fraction to vigorous refining to reduce the particle size of said particles and effect fibrillation thereof, collecting said refined fraction and directing same to said first zone.

3. In the manufacture of paper from wood, wherein the wood is reduced in size and subjected to mechanical, chem-

ical, and/or mechanical-chemical treatment to remove fibers from the lignin or binding constituents of the wood, said fibers being in the form of a suspension in water commonly known as pulp, and where said pulp stock liquid normally includes impurities in the form of bark particles, knots, shives, and the like, the improvement which comprises the treatment of such impurity-containing stock by the following steps, in sequence: forming a dilute aqueous suspension of said pulp stock having a consistency of about 1.2% pulp, introducing said diluted stock into a first zone of vortical flow, thereby effecting vortical hydraulic separation of a fraction low in impurities content from a fraction higher in impurities content due to combined gravitational, rotational and hydraulic forces, introducing said fraction of higher impurity content into a second zone of vortical flow, thereby forming a second set of fractions of high and low impurity content, returning said last-mentioned fraction to said first zone, directing said other high impurity fraction to a third zone of vortical flow, thereby effecting a third pair of fractions of high and low impurity content, returning the last-mentioned fraction to said first zone, subjecting

said last-mentioned high impurity content fraction to a mechanical refining to reduce the size of said impurities, and reintroducing said refined fraction to said diluted pulp stock, said fraction from said first zone, which is low in impurities content, being continuously removed from said first zone and directed to the paper machine.

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