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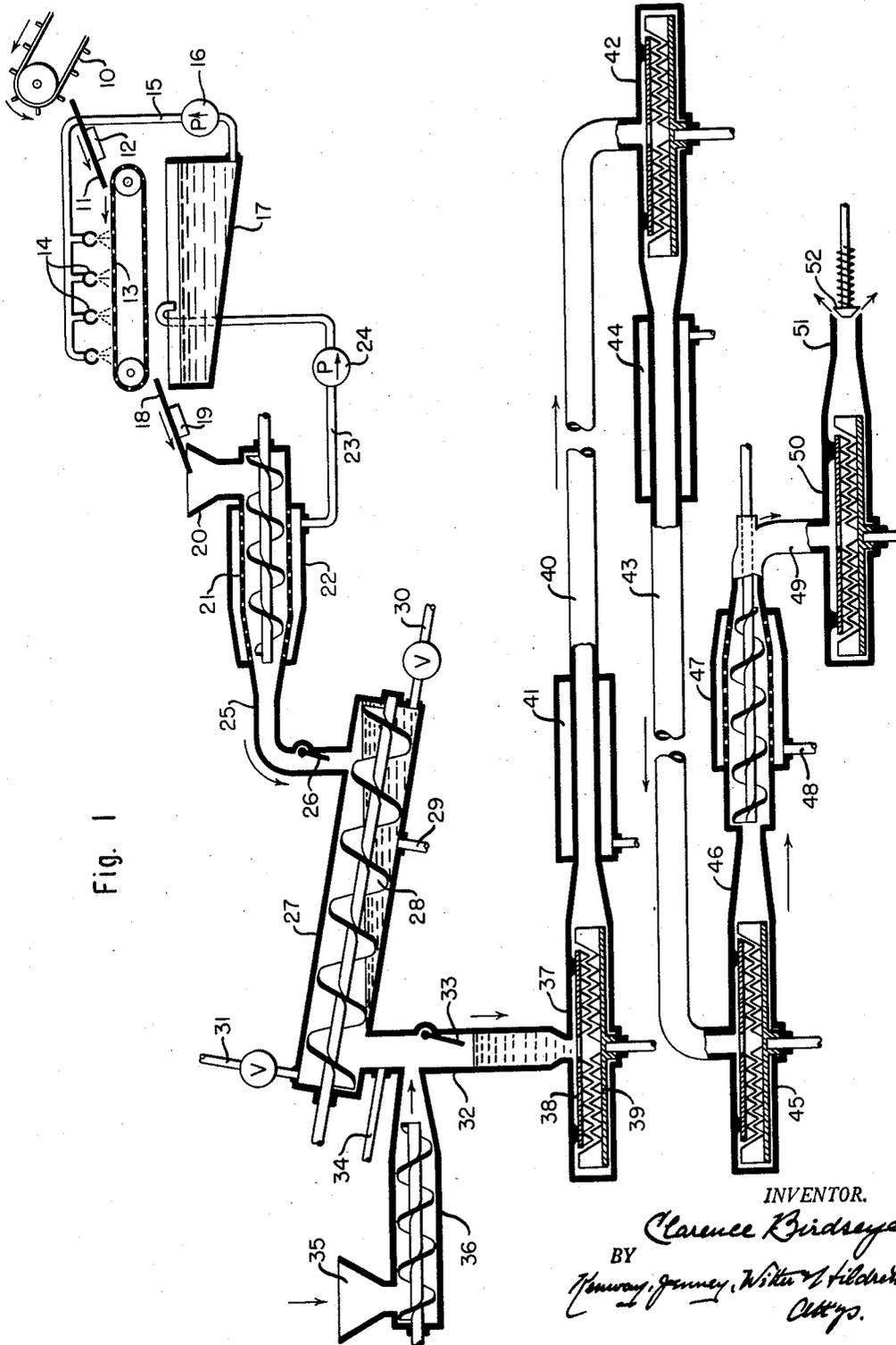
C. BIRDSEYE

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SEMI-CHEMICAL PULPING PROCESS

Filed Dec. 23, 1952

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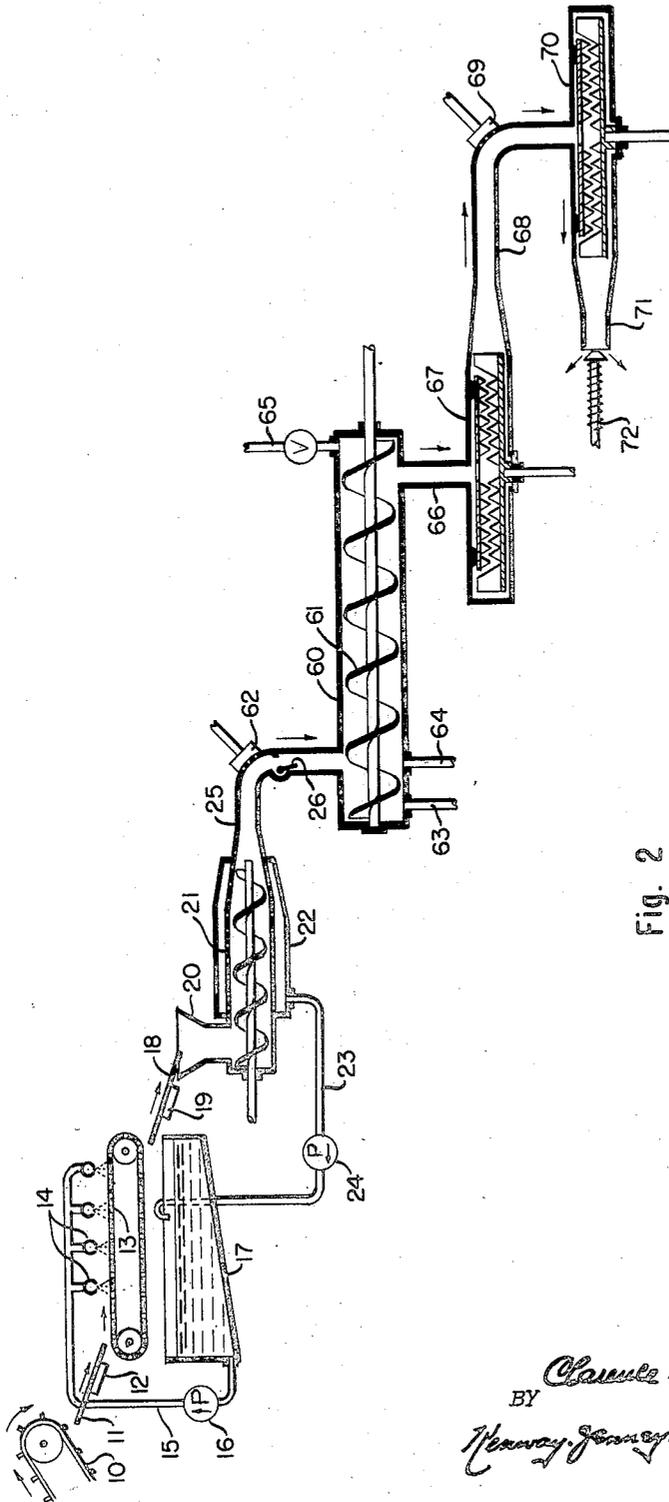


Fig. 2

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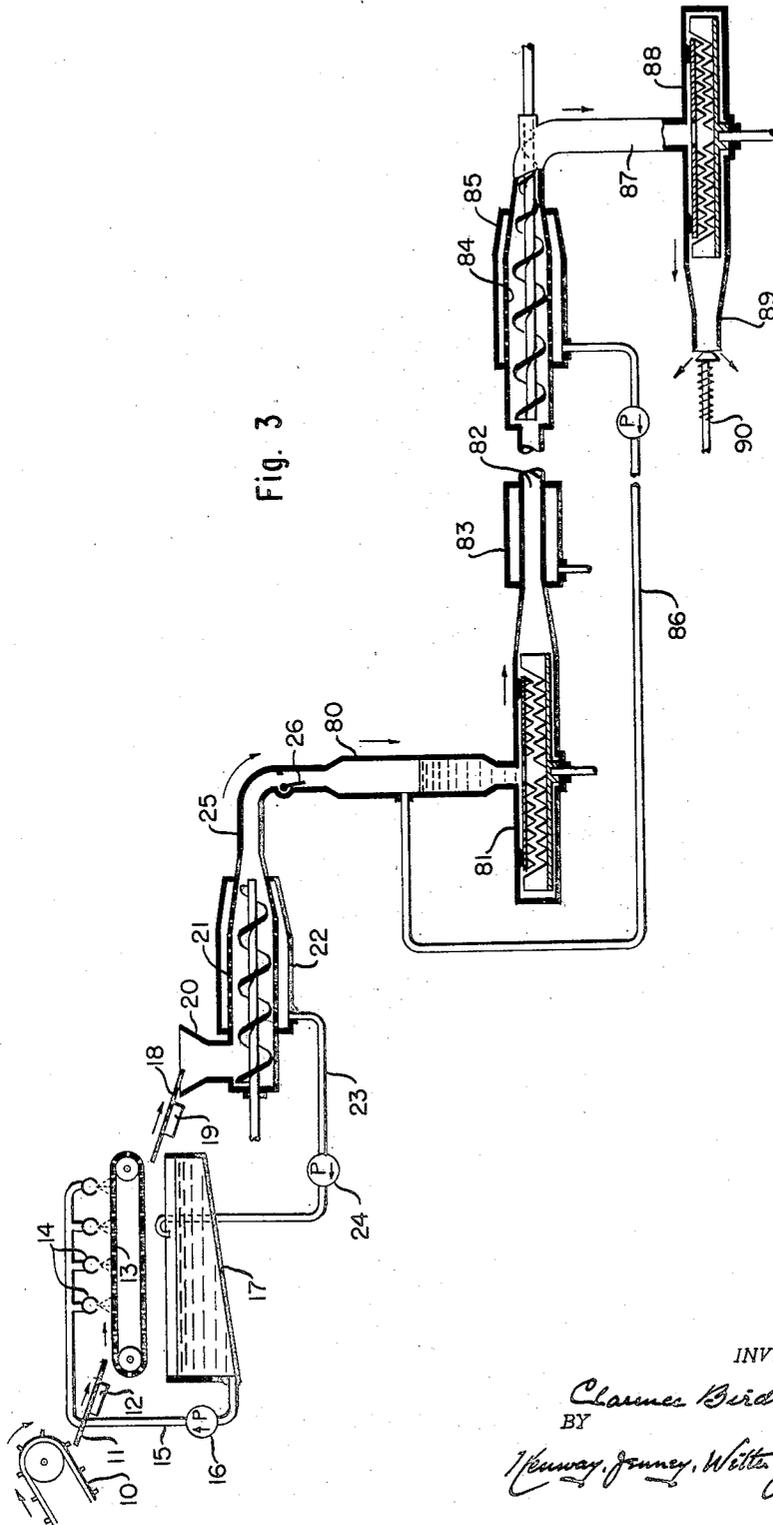


Fig. 3

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1

2,862,813

## SEMI-CHEMICAL PULPING PROCESS

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5 Claims. (Cl. 92—6)

The present invention comprises a new and improved continuous process for producing high-yield pulp of all kinds, including pulp suitable for the manufacture of box board, corrugated board, wall board, and wrapping paper, but not excluding other types of board and paper.

High-yield pulp is usually characterized by relatively large percentages of lignin and/or pentosans and a comparatively low alpha-cellulose content. However, my new process may also be employed in producing with high efficiency easy-bleaching bond-type alpha-cellulose pulps of many sorts. My invention includes within its scope the novel apparatus herein shown as particularly well organized for carrying out the process herein disclosed.

The prime object of the invention is to make available a new continuous process for producing various kinds of pulp by means of maximum physical shredding effects and a minimum consumption of chemical digestants, the process being such that it may be carried out by employing a black liquor spent in use and so lacking in valuable chemicals, such as soda and sulphur, that recovery of those substances from the said liquor is not economically necessary.

Further objects of the invention are to obtain the desirable results above mentioned by employment of apparatus of low first cost, low operating expense, and requiring a minimum of plant space per unit of capacity. With the apparatus herein disclosed the process of my invention may be carried out with extreme speed in the overall time of treatment.

In one form the process and apparatus are particularly suitable for the treatment of wood chips; and in a simpler exemplification are admirably suited for treating grain straws, sugar cane bagasse, bamboo and other plants of the grass family.

Going more into detail, the process of my invention as applied to wood chips is characterized by the steps of repeatedly and alternately shredding ("hot refining") the fibrous material under greater than atmospheric pressure and subjecting the material to brief cooking treatment in a solvent solution both between and during the several shredding steps. Thus the shredding and cooking steps are alternated several times during the course of the process, but cooking also proceeds rapidly while the fibrous material is agitated in the cooking solution during the several shredding steps. In some instances substantially all the necessary cooking may be effected while the fibrous material is in process of being shredded. As a preferred initial step in my process the pieces of fibrous material are showered or otherwise contacted with an appropriate cooking solution, for the purpose of at least partially saturating and softening the said material before it passes through a screw press or other means for delivering it into the pressurized area of the apparatus. Before the final shredding operation the treated fibrous material may be de-watered and the resulting black liquor utilized in any desired way, as for the showering step above mentioned.

2

The process as applied to wood chips is herein illustrated as including four shredding steps, but if desired a fifth shredding and a second de-watering step may be included. The explosion step may be of any desired intensity or may even be omitted entirely. Steaming and deaerating in a cylinder comprising a unit of the apparatus are especially desirable for wood chips.

As pointed out hereinafter, bagasse and the fibrous material from other members of the grass family require somewhat different treatment than that used for wood chips; and the smaller the wood chips the more nearly their treatment may coincide with that described herein for bagasse.

In the apparatus herein shown as preferred for the treatment of wood chips, there are employed centrifugal shredding units modified to serve as powerful pumps and effective to furnish both a considerable suction action and a head pressure up to 50 p. s. i. or more. These centrifugal shredding units will be hereinafter referred to as shredder pumps or hot-stock refiners.

The apparatus and process will be best understood and appreciated from the following description of the novel apparatus shown in its preferred form for purposes of illustration in the accompanying drawings in which:

Fig. 1 is a diagrammatic representation of the apparatus, in flow sheet arrangement, as used in treating wood chips.

Fig. 2 is a similar view of a somewhat modified apparatus, and

Fig. 3 is a similar view of apparatus still further modified and adapted particularly for handling bagasse.

The raw wood chips may be continuously delivered for treatment by a conveyor 10 shown in the upper right hand corner of Fig. 1. The chips fall from the conveyor upon an inclined chute 11 to which is attached a vibrator 12 causing the material to pass freely down the chute to a horizontal mesh conveyor 13. Above the conveyor 13 are arranged a series of spray heads 14 supplied with hot solvent liquid by a pipe 15 and pump 16 leading from a mixing tank 17. By these elements the first step of the process is carried out, that is to say, the fibrous material delivered to the conveyor 13 is showered with hot white liquor supplied by means not shown to the mixing tank 17, or with a mixture of liquors drawn off at subsequent stages of the process and returned to the tank 17 with a predetermined percentage of white make-up liquor. It will be understood that the liquor from the tank 17 is continuously recirculated by the connections described and showered upon the incoming fibrous material. This contacting of the material will thoroughly wet the outer surfaces of wood chips, and will completely impregnate such products as shredded bagasse fiber bundles.

Upon leaving the conveyor 13, the soaked fibrous material falls upon a second chute 18 provided with a vibrator 19 and leading to a hopper 20. The hopper 20 forms part of a screw press 21 having a perforated wall and being surrounded by a jacket 22. The fibrous material is passed through the screw press by the rotation of its helical screw, and excess liquor is expressed and returned through a pipe 23 and pump 24 to the mixing tank 17. The partially de-liquored or de-watered fibrous material is then forced from the screw press into a duct 25, which is herein shown as directed downwardly and provided with a check valve 26. Showering of the fibrous material before it enters the press 21 softens the pieces of material and lubricates them, thereby reducing the power necessary to operate the press and the damage sustained by the cells of the material while passing therethrough. It also permits greater compression of the material in the throat of the press so that

more of the liquid and air are expressed from the material by the formation of a compact plug, thus reducing danger of blow-backs through the press.

The duct 25 leads into the lower end of an upwardly inclined steaming, deaerating and cooking cylinder 27 containing a power-driven screw 28 and having an inlet pipe 29 by which white liquor may be supplied partially to fill the cylinder and maintained at some such level as suggested in the drawings. The cylinder is also supplied with a valved pipe 30 by which depth of liquor in the cylinder may be regulated. Means are provided for maintaining within the cylinder any desired steam pressure, as for example 80 p. s. i. At its upper end the cylinder is provided with a valved steam and air outlet 31. The compressed plug of material is broken up, immersed in hot liquor and advanced toward the left along the cooking cylinder 27. Thus the fibrous material which is finally delivered from the cylinder through a downwardly directed duct or standpipe 32 has been more or less saturated with solvent solution, partially cooked and well de-aerated. The duct 32 is provided with a check valve 33 to prevent blow-backs at this stage of the process, and with an inlet pipe connection 34 by which water or weak digestant liquor at the desired temperature and pressure is supplied in such an amount as to maintain a substantial head of liquor in the duct at substantially the same pressure as that in the cylinder 27. Blow-backs from cylinder 27 to the press 21 are prevented by both the valve 26 and the plug of material formed in the discharge throat of the press 21.

As an additional and optional unit of the apparatus, a hopper 35 is shown as part of a screw feeder-press 36 delivering into the vertical duct or vessel 32. Additional raw material requiring a lesser or minimum of digestion such, for example, as pith or short fine fibers, may be brought into the process at this stage and so by-pass the initial steps of the process above described.

The mixture of partially digested fibrous material and raw material, immersed in the liquor contained in the standpipe 32 is now delivered directly to the center of a shredder pump 37. This unit, as in those later to be mentioned, includes a stationary circular upper plate 38 having downwardly directed preferably pyramidal teeth and a circular lower plate 39 having similar upwardly directed teeth. The lower plate is rotated at high speed by a shaft herein shown as passing from the bottom of the unit, and the effect of the shredder on the partially digested mixture passing through it is to shred the fibrous pieces with the grain of the material and so to separate them progressively into fiber bundles of smaller and smaller size and thus to expose increased surface area for contact with the digestant liquor. Assuming that the material enters the shredder pump 37 at a pressure of 80 p. s. i., it may be further assumed that it is delivered from the shredder to an elongated horizontal duct 40 at a pressure of 110 p. s. i., for example. The shredder pumps 37, 42, 45 and 50 serve as what is known in the pulp industry as "hot stock refiners," and any suitable type of refiner may be substituted for the type of shredder-pump shown herein.

The duct 40 constitutes a digesting zone and may be of any convenient shape, type or length. It is herein shown as provided adjacent to the shredder pump 37 with a reheater 41 by which the temperature of the treated material may be maintained or raised during the portion of the digesting process which occurs in this zone.

The duct 40 is herein shown as directed downwardly at its right hand end and delivering the once shredded and partially digested fibrous material to a second shredder pump 42. This, in turn, discharges into a second digesting duct 43 provided with a reheater 44, and it may be assumed that the shredder pump 42 has increased the pressure upon the material at this point to 140 p. s. i., for example.

The duct 43 is herein shown as directed downwardly at its left hand end and discharging directly into a third shredder pump 45. The shredder pump 45 is provided with an outlet duct 46 leading direct to a screw press 47 which, as before, has a perforated wall and a jacket in which expressed liquor is collected and from which it may be discharged through an outlet pipe 48 and conducted to the mixing tank 17 or otherwise utilized as desired. It may be assumed that in leaving the shredder pump 45 and passing into the outlet duct 46 the pressure to which the material is subjected has been raised to 170 p. s. i.

Any desired type of de-watering device may be used in place of screw press 47. Objectives in removing surplus black liquor at this point in the process are to permit its return (without substantial thermo-dynamic loss) to the standpipe 32, to avoid excessive foaming and unnecessary power consumption in the shredder 50, and to increase effectiveness of the final explosion step, which has been found to be more satisfactory if a minimum of free liquid is present.

The screw press 47 is herein shown as delivering the fibrous material through a down-turned duct 49 to a fourth shredder pump 50 in the system similar to those already described and shown as discharging through an outlet nozzle 51. At this nozzle the shredded material may be maintained at 170 p. s. i., or its pressure may be still further increased to 190 p. s. i., for example. The nozzle 51 may be utilized as an explosion outlet by providing it with a spring-operated plug 52. As the treated material is forced from this nozzle 51 its pressure is dropped abruptly to atmospheric and thus fiber bundles heretofore remaining as bundles are now separated to their ultimate cells by the explosive expansion of vapor between the cells.

It will be understood that any selected or well-known solvent or digestant liquor, such as kraft or soda, may be employed in the process above described, and that when the fibrous material has been once wetted or saturated with this liquor at the initial showering step, the material remains in contact with liquor throughout all the subsequent steps of the process. In general the effect of the pressing operations is to squeeze excess liquor from the fiber mass and to rub apart the fiber bundles. Throughout the entire process the fibrous material remains in contact with the solvent solution and the fiber bundles are repeatedly fractionated or "refined" at elevated temperatures sufficiently high to soften their lignin content and thus prevent the rupture of the individual cells of which they are composed.

The apparatus above described is particularly adapted for carrying out the continuous process of my invention for pulping wood chips at a rate of speed not hitherto considered practicable in the industry. For example, black spruce wood chips may be passed through the entire apparatus within 20 minutes, and not more than five minutes need elapse between successive shredding operations.

In pulping bagasse and other pithy fibrous materials by the method and apparatus of the present invention I prefer first to remove at least part of the pith cells and to shred and wash the fiber bundles so that they resemble short pieces of very fine excelsior. This may be accomplished by the process set forth in my co-pending application Ser. No. 286,237, filed May 6, 1952, now Patent 2,723,194, or in any other suitable manner.

In producing kraft pulp from bagasse fiber bundles I prefer to impregnate the bagasse thoroughly with a very hot (about 190° to 215° F.) solution containing from 15 to 50 grams per liter of NaOH, and having a sulfidity of from 10 to 40 percent. Bagasse fiber bundles showered with or immersed in any such liquors at the specified temperatures for ½ to 1 minute will pick up about 4 to 5 times their own weight of liquor and will be thoroughly and evenly impregnated therewith after the first squeezing

5

step to which they are subjected in passing through a screw press.

In Figs. 2 and 3 is illustrated apparatus of this invention organized and operating for pulping bagasse. In these figures the units for delivering, impregnating the bagasse under atmospheric conditions and for de-watering or de-liquoring it are shown as corresponding to units illustrated in Fig. 1 and are designated by the same reference characters.

In Fig. 2 the screw press 21—22 is shown as discharging through the right angled duct 25 into a horizontally disposed cooking cylinder 60 containing a screw conveyor 61. The bend of the duct 25 is perforated and provided with a manifold 62 from which black liquor or other fluid under pressure is blown into the bend in order to dislodge the compressed fibrous material emerging from the press and cause it to pass down the vertical leg of the bend to the cooking cylinder 60.

The cooking cylinder is provided with a steam inlet connection 63 and a white liquor inlet connection 64. The bagasse may be subjected in this cylinder to a cooking or digesting step at perhaps 200 p. s. i. in duration about five or six minutes. The compressed plug of material at the discharge end of the screw press 21—22 will ordinarily prevent blow back from the cylinder but the check valve 26 further safeguards against that contingency. A valved outlet connection 65 is provided near the discharge end of the cylinder 60 by which steam and air may be removed from the system.

The cooking cylinder 60 is provided with a downwardly extending discharge duct 66 leading directly to the center of a shredder pump 67 wherein the now substantially digested fibrous material is hot refined or fractionated while saturated with hot digestant liquor thus increasing the exposed area of the remaining fiber bundles without interrupting the digesting process.

From the shredder pump 67 the refined fibrous material is discharged, preferably at somewhat increased pressure, to a right angle duct 68. This is shown as provided with perforations in its bend and a manifold 69 for supplying fluid pressure to advance the material through the vertical leg of the duct and to a second shredder pump 70. Here the fibrous material is subjected to a second hot refining step and its pressure may be still further increased. Finally, the material is discharged at full pressure through an outlet nozzle 71 controlled by a spring pressed plug 72 so that the emerging fibrous material is explosively disintegrated into its ultimate cells. It will be apparent that black liquor collected from the jacket 22 of the screw press may be conducted to either or both of the manifolds 62 and 69 in accordance with the condition of the material under treatment.

In Fig. 3 is shown apparatus organized and operating pulping bagasse without subjecting it to a separate cooking or steaming step such as that carried out in the cylinder 60 of Fig. 2. This is a practical procedure in producing kraft pulp from the raw material. Accordingly, the screw press 21—22 is arranged to discharge through the duct 25 downwardly to the standpipe 80 to which it will deliver the saturated bagasse compressed and freed from surplus liquor at a pressure of 80—100 p. s. i., for example.

Because of the thorough impregnation of the fibre bundles with relatively concentrated solvent solution, the liquor thereafter added to them may be much weaker than that with which they have been initially impregnated. In fact, in the production of high yield kraft pulps I prefer not to add any digestant after the impregnated fibre has passed through the press 21—22. The liquid maintained in the standpipe 80 preferably comprises hot water and weak black liquor removed by a de-watering press operating at a later stage in the process. When this procedure is followed, the black liquor finally emerg-

6

ing with the pulp will contain so little soda or sulphur that waste will be negligible.

The standpipe 80 is shown as directly connected to the center of a shredder 81 which is arranged to discharge the liquid-borne fibre under increased pressure to a digesting duct 82. This is provided adjacent to the shredder with a heating device 83 by which the temperature of the product passing through the duct 82 may be elevated. The duct 82 leads directly to a second screw press 84 having perforated walls surrounded by a jacket 85 in which the liquid expressed from the fibrous material is collected and from which it may be returned through a pipe line 86 to the standpipe 80.

The screw press 84—85 discharges into a down-turned duct 87 which leads to the center of a second shredder 88. This is arranged to discharge through a nozzle 89 controlled by a spring pressed plug 90. At this point the final disintegration of the fibre cells is caused to take place by the explosive expansion of the compressed vapor contained in the product.

It is proposed to deliver to the mesh conveyor 13 of the apparatus shown in Fig. 3 coarse whole bagasse or shredded fibre bundles of bagasse which have been baled and transported from the sugar mill to the pulping apparatus. This is impregnated with relatively concentrated white liquor at a temperature of about 210° F. and at atmospheric pressure. It then passes to the screw press 21—22 at atmospheric pressure where excess liquor is expressed, the fibre bundles broken apart along their grain by rubbing, de-aerated and advanced from the press into the high pressure zone of the apparatus at a pressure of about 100 p. s. i. in the standpipe 80. At this stage the fibre bundles are submerged in a less concentrated liquor such as hot water and black liquor collected from the screw press 84—85.

The fibre bundles are then subjected to further shredding or hot refining by the action of the shredder 81 from which they emerge at an increased pressure of about 150 p. s. i. In passing through the digesting duct 82 the temperature of the product may be increased with advantage to 240—250° F. by the action of the heater 83. At the screw press 84—85 excess black liquor is removed and the digested fibrous stock is delivered to the shredder 88 with a minimum of liquor, thus conserving the power required for the final hot refining step and avoiding foaming. The fibre bundles, almost completely disintegrated, emerge from the nozzle 89 under pressure still further increased by the action of the shredder 88 and complete disintegration of the cells is caused by the explosive release of the compressed vapor.

The lapsed time of treatment from the hopper 20 to the nozzle 89 will usually be from 3 to 10 minutes depending upon the concentration of the solvent solutions employed and the type of pulp desired.

It will be apparent that the process above described not only greatly reduces the time heretofore required in pulping bagasse and the like, but also reduces the amount of valuable chemicals leaving the apparatus so as to obviate the necessity for solvent recovery installations at the pulp mill. The apparatus required, moreover, is compact and forms a self-contained system that may be operated twenty-four hours a day if desired, and under these circumstances it is apparent that units of moderate capacity may be successfully employed in the treatment of a large product volume.

Having thus disclosed my invention and described in detail illustrative examples thereof, I claim as new and desire to secure by Letters Patent:

1. In a continuous process of pulping vegetable material, the steps of wetting pieces of the raw material under atmospheric conditions with digestant solution, adding further solution to the wetted pieces at more than atmospheric pressure, advancing and simultaneously partially cooking the mixture thus formed, then adding to the partially cooked mixture additional pith and short fine

7

fibers requiring a lesser degree of digestion thus by-passing the initial steps of the process, shredding the material thus collected, and conducting the mixture of partially cooked and raw materials through a digesting zone.

2. A continuous process of pulping vegetable material, comprising the steps of contacting the material with digestant liquor, compressing the material into a compact plug and removing excess liquor therefrom, partially cooking the material of the plug by breaking it up and advancing it through a cooking zone, thereafter adding to the partially cooked material short fine fibers requiring a lesser amount of digestion, and subjecting the mixed ingredients to shredding, compression and explosive expansion, whereby the two ingredients of the said mixture are differentially treated in the same process.

3. A continuous process of pulping vegetable material as defined in claim 2, in which the partially cooked and raw ingredients of the mixture are simultaneously and repeatedly shredded alternating with subjecting the mixture to brief cooking treatment in a solvent solution between the several shredding steps.

4. In a continuous process of pulping bagasse or the like, the steps of impregnating pieces of bagasse under atmospheric conditions with a hot digestant solution, compressing impregnated bagasse into a pressure-resisting mass and removing excess solution therefrom, releasing and mechanically advancing the mass through an elongated cooking zone while immersed in fresh digestant solution, thereafter adding to the partially cooked bagasse pith and short fine fibers requiring a lesser amount of digestion, and then passing the partially cooked mixture

8

back and forth in an elongated path in which the mixture is subjected to repeated and alternate shredding and cooking steps under increased pressure and heating steps.

5. A continuous process of pulping bagasse or the like comprising the steps of impregnating pieces of bagasse under atmospheric conditions with digestant solution, partially cooking the impregnated pieces, thereafter adding to the partially cooked bagasse pith and short fine fibers requiring a lesser amount of digestion, then subjecting the mixture to a shredding step while under superatmospheric pressure, passing the fibrous shredded pieces in solvent mixture and under increased pressure through an elongated horizontally disposed digesting zone, meanwhile supplying heat from an external source to the mixture, and then subjecting the fibrous portion of the mixture to a further shredding step under still further increased pressure.

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