

[54] **CYCLONIC DIGESTER SYSTEM AND PROCESS**

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[58] Field of Search **162/19, 23, 17, 24, 57, 162/234, 241, 242, 237, 243, 244, 248; 209/211**

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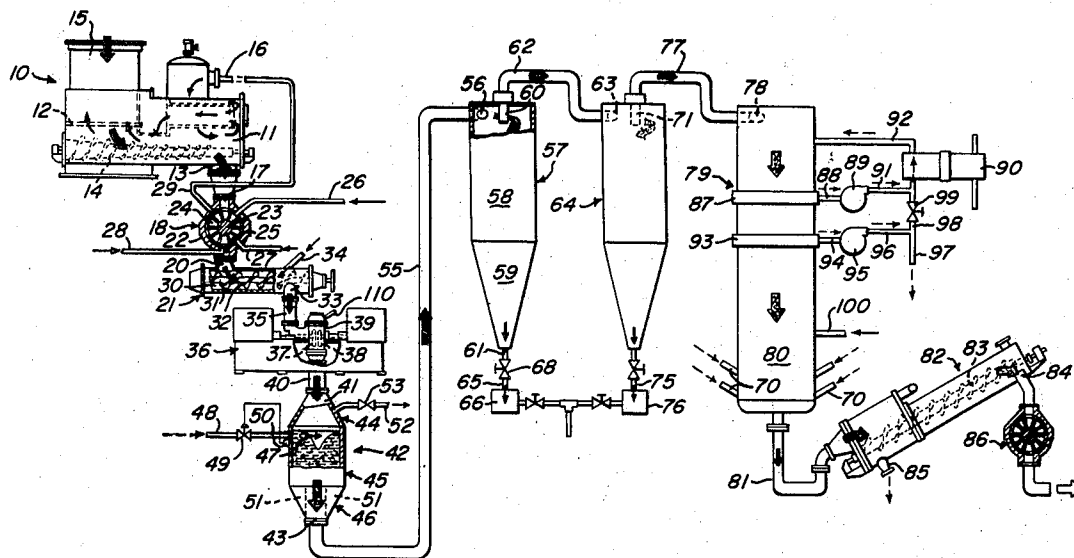
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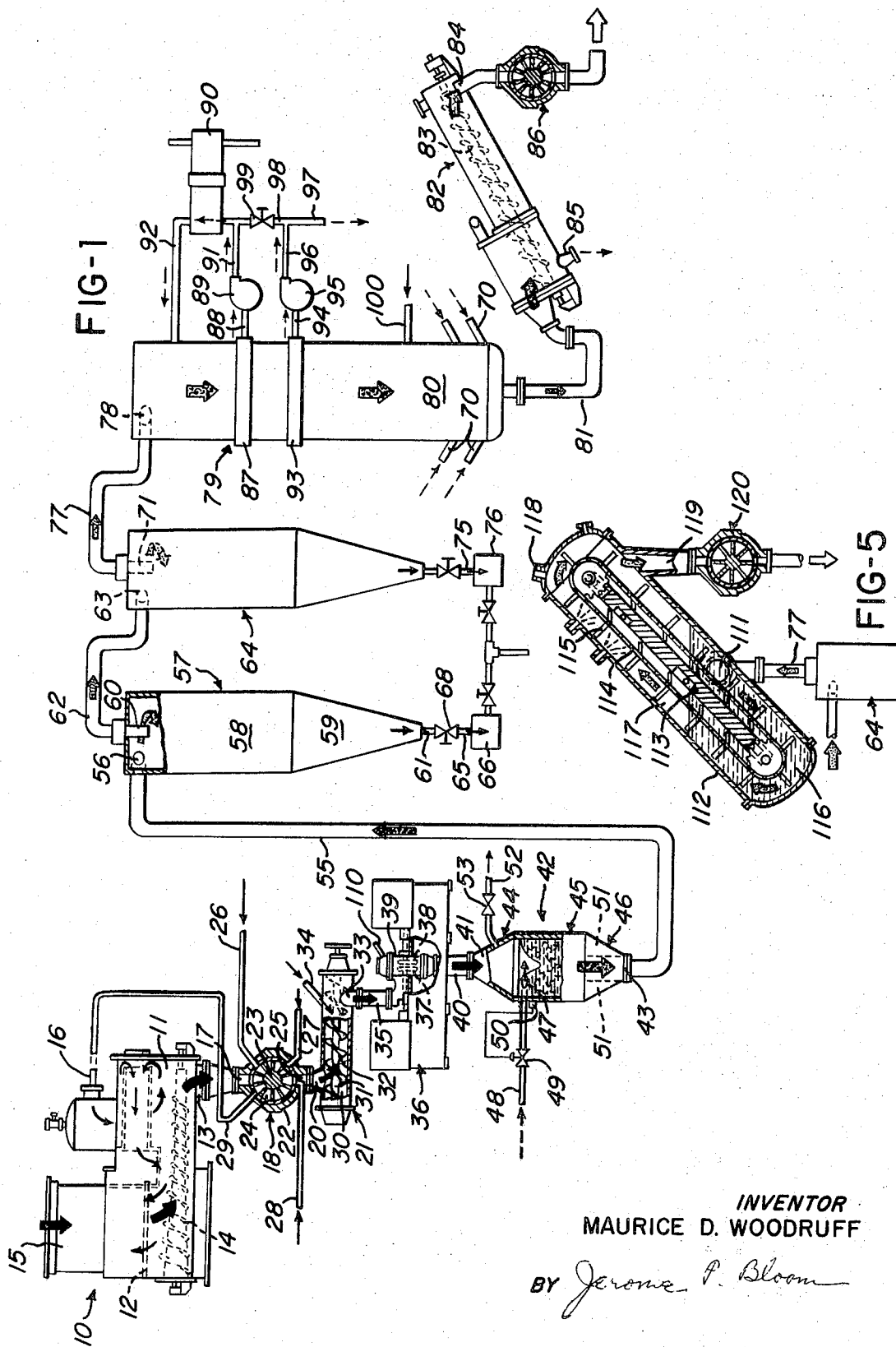
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ABSTRACT

The invention system and process provides for a cyclonic digesting of fibrous pulp in a pressurized environment. It utilizes a double revolving disc refiner which reduces raw wood or like fibrous content material into fibers and fiber bundles. It features the use of a plurality of chambers in which the fiber content, as discharged from the disc refiner, is successively subjected to a vortex flow pattern under the influence of conditioning fluid such as a cooking liquor. The invention provides in this manner that lignin and other non-fibrous materials which attach and normally tend to coat and cling to the fibers are substantially solubilized and/or dissipated. The fibers resulting are not only simply and economically made individual but of such nature as to facilitate the production of high quality paper products, including, in particular, an improved Kraft.

37 Claims, 6 Drawing Figures

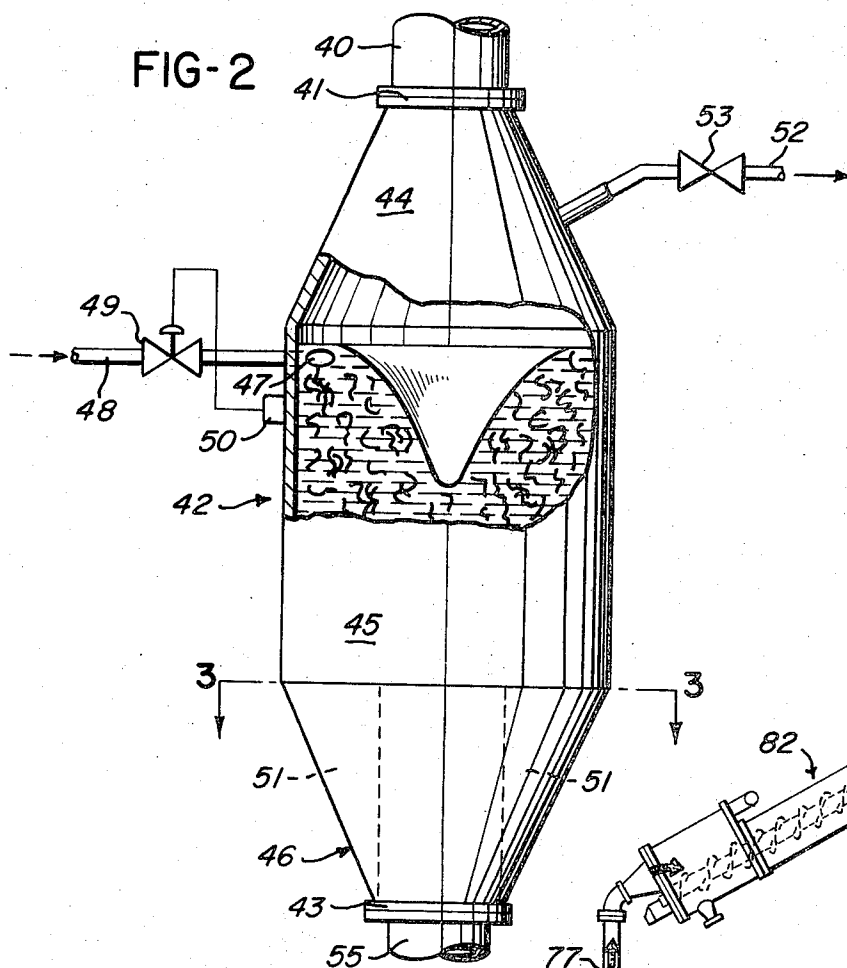
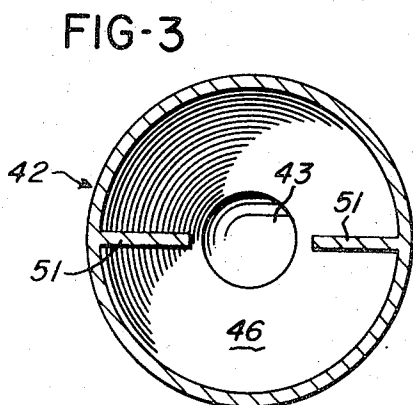
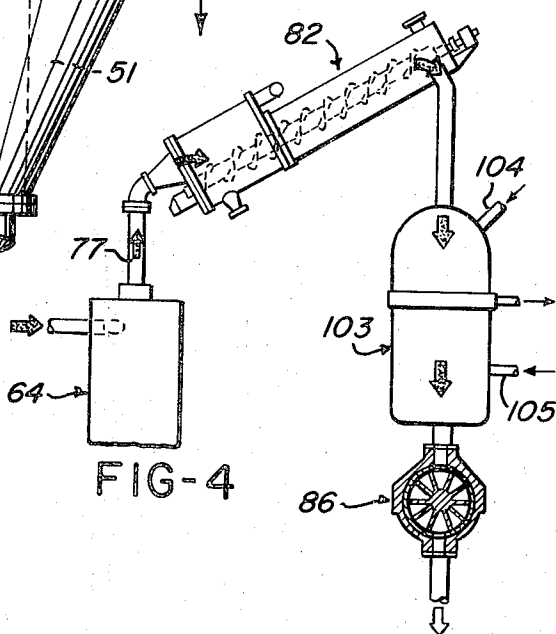




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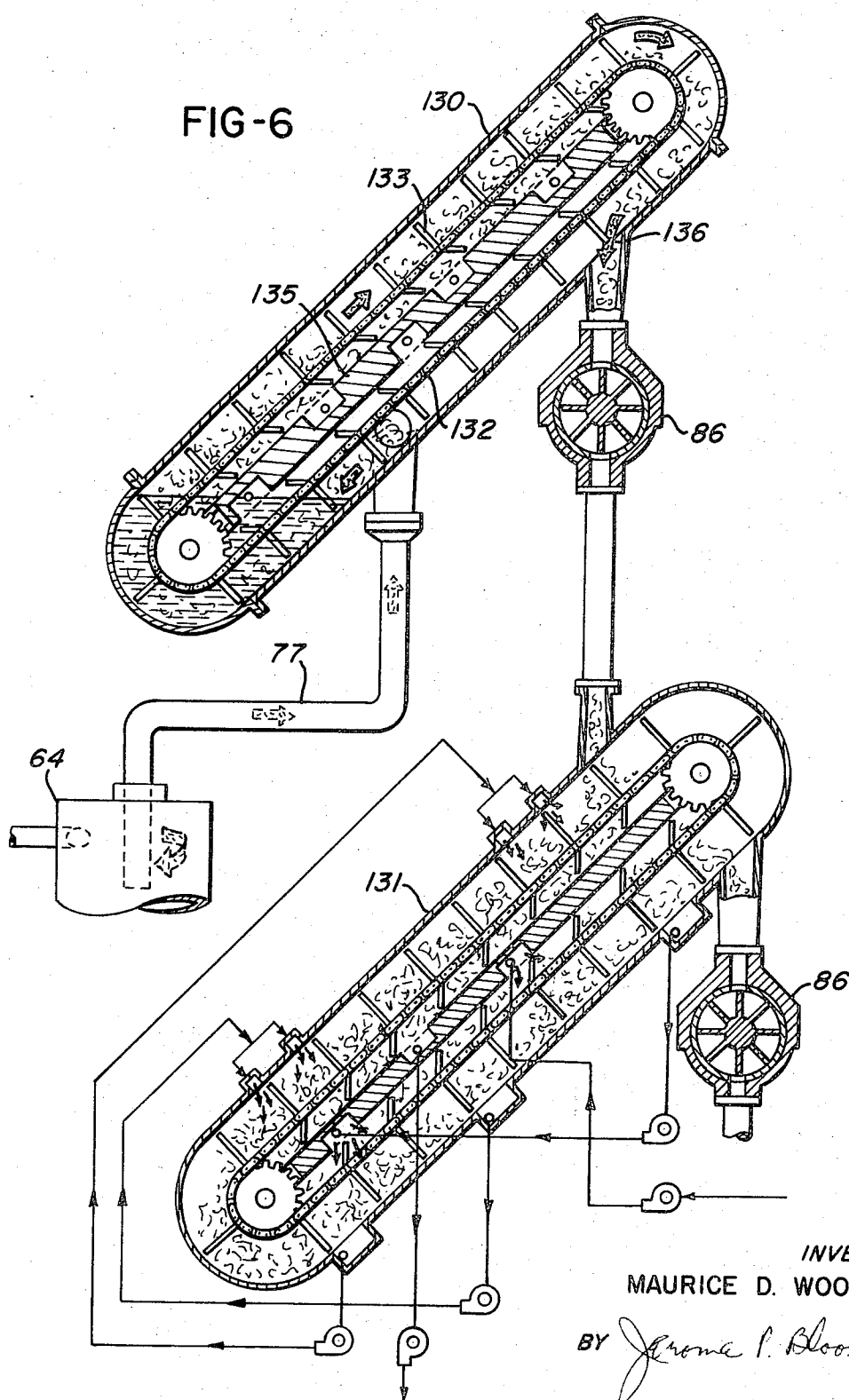
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CYCLONIC DIGESTER SYSTEM AND PROCESS

BACKGROUND OF THE INVENTION

This invention relates to a new and improved system and process for reducing and digesting raw fibrous material. It is particularly applicable to the conversion and preparation of raw materials for use in paper products and will be so described by way of illustration.

The Pulp and Paper Industry is continually striving for better pulp fibers at least cost. There have been many innovations in the industry which have lent advances in this direction. However, with each innovation it has been found that problems still remain in certain areas of application. For example, new concepts of pressurized double revolving disc refining and the practical use thereof have come to light only in recent years. The reduction to practice of such new concepts has resulted in a minimizing of equipment, time and labor required in the reduction of raw wood materials to a desired fiber form. However, while the art has been substantially advanced in this direction by the various systems and processes proposed, problems have still remained in respect to reducing certain raw materials to an individual fiber form and one in which the normally adherent lignin and non-fibrous particles are fully dissolved and dissipated, as desired for certain end product usage. Apart from this, there has been evidenced in available pulp digesting procedures a need for improvement. The problem has been to achieve as complete a digesting as may be required and at the same time to further minimize the time, equipment and materials necessary for such objective. It is noted that the present invention is directed to a common solution of these problems which exist in the art.

SUMMARY OF THE INVENTION

This invention provides a means and method for rapidly and most effectively converting raw fibrous material into essentially individual clean fiber elements. The system is characterized by a pressurized environment in which the raw material is initially reduced to fibers and fiber bundles in a double revolving disc refiner and immediately thereafter subjected to a digesting operation in the course of which the materials issuing from the refiner are subjected to a staged vortex forming flow pattern. In the course of this vortex type movement the fibers are spread, separated and continuously and increasingly exposed to a digesting or cooking liquor. The net result is a solubilizing to a maximum degree possible of the coatings and attachments which normally adhere to the fibrous material. Means are provided for dissipating of the inorganic material attendant the fibers and for a conclusion of the digesting process prior to discharge of the so conditioned fibers to an atmospheric environment. The resultant fibers will be in a condition optimally suiting the same for further treatment, if desired, and for application to end products, as will be self evident from the following description of a preferred embodiment and practice of the invention.

It is therefore a primary object of the invention to provide an improved system and process for digesting cellulosic material which is economical, more efficient and satisfactory in use and adaptable to a wide variety of application.

Another object of the invention is to provide a new and improved cyclone digesting system enabling a unique cyclone digesting process.

Another object of the invention is to provide an improved means and method for converting raw material of fibrous content to individual fibers relatively free of coatings or attachments.

A further object of the invention is to provide a new and improved digesting system for fibrous materials wherein any attachments to or coatings of the fibers thereof is quickly and effectively dissolved and/or dissipated.

A further object of the invention is to provide a pulp refining system featuring a staged digesting segment including means for achieving a vortex forming flow of pulp material under the influence of a digesting or cooking liquor and in a manner subjecting the material to changing pressures.

An additional object of the invention is to provide a new pulp refining system and process possessing the advantageous features, the inherent meritorious characteristics and the means and mode of use herein described.

Another object of the invention is to provide a pulp digesting system and process possessing the distinctive features and characteristics herein set forth.

With these and other incidental objects in view as will more fully appear in the specification, the invention intended to be protected by Letters Patent consists of the features of construction, the parts and combinations thereof, and the mode of operation as hereinafter described or illustrated in the accompanying drawings, or their equivalents.

Referring to the drawings wherein one but not necessarily the only form of embodiment and application of the invention is shown,

FIG. 1 is a generally schematic arrangement of the elements of a pulp refining system in accordance with the invention, elements thereof being generally diagrammatically illustrated;

FIG. 2 is an enlarged view of a segment of a system of FIG. 1;

FIG. 3 is a cross sectional view taken on line 3—3 of FIG. 2; and

FIG. 4 is a view illustrating a modification of the invention.

Like parts are indicated by similar characters of reference throughout the several views.

Looking now to the accompanying drawings, in the system and practice of this invention raw wood chips, for example green black spruce of 40 to 50 percent moisture content, are first introduced to a preconditioner 10. This unit may be such as shown in U.S. Pat. No. 3,471,364. Here, however, only such detail is shown as may be necessary of an understanding of the type of essentials required in the practice of the invention. As illustrated in the drawings, preconditioner 10 is a vessel within which is formed a tubular chamber 11 leading from an inlet 12 to its top at one end to an outlet 13 at its bottom to its opposite end. Mounted for rotation in the chamber 11, and extending from end to end thereof, is a feed screw 14. Projecting upward from the vessel 10 is a vertical charge tube 15 the lower end of which is sealingly related to rim the inlet 12. Immediately below the inlet 12, as previously noted, is one end of the screw 14.

As will be readily apparent, a charge of raw wood chips may be introduced to and maintained in the tube 15 to form a vertical column thereof extending upwardly of the screw 14 and the inlet 12. Suitable means are provided for rotating the screw 14, whereupon the screw will pick up and move chips from the bottom of the chip column to the outlet 13. The chips drop through this outlet under the influence of gravity and the pressuring influence of the continuing flow of chips being delivered by screw. Connected into the chamber 11 adjacent its outlet is the delivery end of a steam conduit 16. The steam is so delivered to move through and counter to the chip flow to exit by way of inlet 12 to and through the chip column in the tube 15. This steam acts to drive air from the chips and to raise their temperature. The chips so heated and conditioned, but otherwise in their raw natural form, pass through the outlet 13 and, by way of an interconnecting conduit, to the inlet 17 of a rotary valve 18.

Valve 18 is preferably of a type similar to that shown in U.S. Pat. No. 3,273,758 which issued to J. R. Starrett on Sept. 20, 1966. Such valve is designed to form a first pressure seal in the invention system. It passes chips exiting from the preconditioner outlet 13 to and through an inlet 20 opening from the top of a horizontally oriented conditioning vessel 21 while maintaining a pressure seal across the inlet 20.

As schematically shown, the valve 18 includes a housing 22. Suitably driven (clockwise in the case illustrated) and bearing in the housing 22 is a rotor 23. Opening from the periphery of this rotor is a series of circumferentially and equidistantly spaced pockets 24. As the rotor is driven, each pocket 24 successively presents itself in alignment with the valve inlet 17 to receive therein a charge of chips and to carry the same to discharge on registration thereof with an opening in the housing 22 which defines a valve outlet 25. As here provided, as each pocket leaves the valve inlet 17, its contents are pressurized by an introduction of steam from the discharge end of a steam conduit 26 installed in an opening in housing 22. As each pocket commences to open to the valve outlet, the charge therein is exposed to a first scavenging flow of steam delivered from a conduit 27 the discharge end of which is also installed in the wall of housing 22. Conduit means 28 are conventionally provided on the far side of the outlet 25 to produce a further scavenging flow of steam or other fluid which is moved across the wall of each pocket to produce an effective discharge of its contents to the inlet 20 of the interconnected vessel 21. The scavenging of the pockets thus facilitates a clean discharge of their contents to the pressurized environment of the conditioning vessel 21, leaving in each pocket a pressured charge of hot steam. This steam is vented from the housing 22 by way of a discharge conduit 29 to which each pocket is exposed prior to registering once more with the valve inlet 17. As each pocket reaches the inlet once more, it receives a fresh charge of chips which are cycled to the valve outlet in the manner as just described.

The vessel 21 is shown as a horizontally disposed, digester type cylinder which defines therein a tubular chamber 30. A shaft 31 is rotatably supported in the chamber 30 to extend the length thereof. This shaft, which is motor driven, is bladed to form a helical screw conveyor unit 32. As the shaft rotates, the screw unit picks up the chips as they enter the inlet 20 and carries

them the length of the chamber 30 to a remote point of discharge defined by an outlet 33 at the bottom of the vessel 21. As schematically illustrated, a conduit 34 is interconnected with the vessel 21 to open and deliver steam to the interior of the chamber 30 to produce therein a pressurized environment wherein the pressure level is approximately 150 p.s.i.g. and the temperature level is approximately 366°F. The movement of the steam in chamber 30 is directed counter to the chip flow, in the process of which to condition the moving chips by heating them to system temperature without creating any significant free moisture. The temperature, pressure level and nature of the steam is such to cause a softening of the lignin and other bonding agents between the fibers of the moving chips. Conditioning chemicals of liquid form may also be injected in the chamber 30 but such is limited to avoid the creation of free liquid which would be entrained with the conditioned chips. Accordingly, whether the conditioning medium is introduced to the vessel 21 in a gaseous or liquid state, care is taken to avoid any excess or free liquid attending the chips as they are delivered through the outlet 33. From the latter point they are caused to directly enter the feed inlet chute 35 of a double revolving disc refiner 36. The latter is also a pressurized unit the interior of which is in free communication with the interior of vessel 21 and has therefore a common pressurized environment.

A pair of refiner disc units 37 and 38 are contained in the housing 39 of the disc refiner 36. The discs are so arranged to have their operating surfaces in immediately opposed and closely adjacent relation. Suitable motor means are connected to rotate the discs in opposite directions at high speed. With such conditions prevailing, the chips move through the feed inlet 35 and through openings about the center of disc unit 37 to a space between the centers of the disc refining units. The construction of the disc units provided, in known manner, at their centers is such that on relative rotation of the discs the chips are caused to move radially outward between the disc operating surfaces. In the process the raw chips are rapidly and gently reduced to single fibers and fiber bundles which issue from between the disc units at their peripheries.

In the reduction of chips to the form of fibers and fiber bundles in the refining zone of the double revolving disc refiner 36, by virtue of the environment each separated fiber issuing from between the operating faces of the discs will be encased in semi-fluid lignin. Of course, those fibers which issue in bundle form will also be encased in a semi-fluid lignin both exteriorly and interiorly of the bundles. As the fibers and fiber bundles are issued peripherally of the refining discs, they impact on the inner wall surface of the refiner housing 39 and are directed thereby to exit from the bottom of the housing through an outlet chute 40 which connects the discharge of the refiner to the inlet 41 opening from the top of a vertically oriented mixing or digesting vessel 42.

The vessel 42 is a hollow shell defining a continuous vertical chamber from its inlet 41 at the top to its outlet 43 at its bottom. While uniformly circular in cross section, the chamber in vessel 42 includes three distinct sections, respectively identified, from top to bottom, by the numbers 44, 45 and 46. The upper section 44 has a generally conical configuration, expanding downwardly from the vessel inlet to merge with the upper

end of the intermediate section 45 which has a uniformly cylindrical form and substantial vertical height in comparison to the height of either of the sections 44 or 46. Of course, the diameter of the uniformly cylindrical section 45 is the same as that of the largest diameters of the sections 44 and 46 with which it merges. The section 46 has a configuration generally identical with that of section 44 but inverted in form, its truncated apex disposing lowermost and defining the outlet 43 at the bottom of the vessel 42. Adjacent the upper end thereof the intermediate chamber section 45 has an inlet 47 arranged to direct fluid interiorly thereof in a sense tangential to its defining wall structure. Interconnected with the tangential inlet 47 is the discharge end of a conduit 48 incorporating a control valve 49. The conduit 48 is interconnected with a supply of cooking or conditioning liquor and functions to deliver the same in quantities determined by a control device 50, which is in contact with and senses the level of liquid in the vessel 42 by reacting to change in pressure in the liquid referenced to a predetermined level. Generally speaking, it is required that the level of liquor in the vessel 42 be maintained to the top of the chamber section 45 and the control device 50 will govern the setting of the valve 49 in a conventional manner to insure that this condition exists. Note also that a pair of radial vanes 51, arranged in a generally common plane, are incorporated in connection with the chamber wall in section 46. As will be obvious from FIGS. 2 and 3 in the drawings, the radially innermost vertical edges of the vanes 51 are spaced apart a distance slightly greater than the diameter of the outlet 43. Also incorporated to open to the chamber section 44 in the vessel 42 is a vent line 52. The latter incorporates a one way valve device 53 to insure there may be a controlled escape from the vessel 42 of noncondensable and other gases released from the wood chips without danger of exposure of its contents to an environment other than the pressurized environment which has been established in the system.

The mixing or digesting vessel 42 functions as follows. It receives through its inlet 41 the refined chip discharge from the refiner housing 39. A positive discharge to the vessel 42 is insured by the injection of shower water in the refiner housing 39 by way of conduit means schematically shown at 110. This water acts on the fibers and fiber bundles issuing from between the disc refiner units 37 and 38 to direct them downwardly to the chute 40. As noted previously, the resultant fiber products, both in individual and bundle form, are encased in semi-fluid lignin. In the course of entering the chamber section 44 and vessel 42, the conically expanding form of the section 42 permits that the fibers and fiber bundles relatively expand into a spray form as they drop to the level of the liquor maintained to the height of the upper extremity of the intermediate chamber section 45. As this drop occurs, the valve 53 in the vent line communicating with the chamber section 44 will be controlled to provide for a metered gas and steam bleed. As a result, by this cautionary practice there will be prevented even a minute accumulation of air in the materials as they are phased through the conditioning or digesting portion of the invention system.

As noted previously, in the exercise of the system and process of the invention a continuing flow of cooking or digesting liquor will be delivered through the con-

duit 48 to enter tangentially of the wall of the chamber section 45 by way of the tangential inlet 47. Under the circumstances, the entering liquor will be constrained to move in a swirling path to create thereby within the chamber section 45 a vortex type flow pattern. Due to this vortex type flow pattern of the incoming cooking liquor which is continuously fed to maintain the level as described, together with the construction of the mixer or conditioning vessel 42, there is produced a profile on the upper level of the swirling liquor wherein there is a central depression of conically reducing form. With the arrangement so provided, as the lignin encased fibers and fiber bundles hit the level of the swirling liquor, under the influence of gravity, they are caught up in the liquor profile and thereby entrained and induced to flow in the established vortex like pattern. Since the cooking liquor continues to enter tangentially and the vortex flow is continuously maintained, the fibers will immediately be subjected to separating forces. The flow pattern will produce an immediate and continuing wetting of the fiber surfaces in the process of which to produce a continuing digesting effect on the lignin casing. Due to the type of movement of the fiber in the vessel chamber section 45, rather than the liquor adjacent the fiber elements becoming saturated with lignin dissolved thereby as in conventional digesting procedures, the fiber in its continuous movement is constantly being exposed to unsaturated liquor which is capable of accommodating and effecting additional solubilizing action on the lignin casing still remaining.

As was pointed out in the first instance, the raw chips as moved to the disc refiner housing 39 were preferably handled so as to maintain them substantially free of excess or entraining liquid. Thus, to the point of refining and discharge from the disc refiner, considering the example first indicated, the consistency of the fibrous material entering the vessel 42 is, in the example of green black spruce illustrated, in the neighborhood of approximately 50 percent. However, it will be recognized that, depending on the raw material, the consistency may be as low as 30 percent. In any case, in the preferred practice of the invention the liquid movement will be so controlled in the vessel 42 that the fiber products of refining will issue from the vessel 42 in a slurry form having a consistency of approximately 4 percent.

As provided, the function of the vessel 42, particularly in its intermediate chamber segment 45, is to create a further reduction of the interconnection between the fibers and an increased separation of fibers, one from the other, in the process of which there is produced a changing and thorough exposure of the fibers to the cooking or conditioning liquor. This not only produces a wetting of the fiber content but influences, under the temperature and pressure conditions provided in the pressurized environment, an extended solubilizing of the lignin and other materials which would normally cling, coat and tend to attach to the fibers. This is of significant importance in achieving a fiber end product best suited for the greatest variety of use in accordance with the invention.

Attention is now directed to the vanes 51 provided in the bottom section 46 of the vessel 42. The function of these vanes is to break up the vortex flow of the fibrous material in movement thereof from the vessel 42 through the outlet 43. The reason for this is to prevent

a vapor core being created the length of the chamber within the vessel 42 which would create a risk of an entrainment of air from the preceding portion of the system. If this were permitted to happen, this would degrade the fibers in their continuing transit through the system.

There is thus provided within the vessel 42 a control of liquid and fiber movement insuring a best conditioning of the fiber content and means are provided inhibiting any air inadvertently being entrained with the fiber product leaving the mixing or conditioning vessel 42.

A conduit 55 sealingly connects at one end about the outlet 43 of the vessel 42 and has its other end similarly connected about the tangential inlet 56 of a cyclonic digester 57. The latter has a shell-like form defining an interior chamber the configuration of which includes an upper vertically extended uniformly cylindrical portion 58 and a lower conically reducing portion 59. The tangential inlet 56 opens to the upper end of the cylindrical portion 58 adjacent its end closure which centrally incorporates a co-axial tube defining its overflow outlet 60. An underflow outlet 61 is defined at the lowermost or apex of the chamber portion 59.

As previously mentioned, the fibers issuing in both single and grouped form from the vessel 42 will be carried in a flow of approximately 4 percent fiber consistency. This flow will be delivered by way of conduit 55 into the upper uniformly cylindrical chamber portion 58 of the cyclonic digester shell 57. The shell 57 provides a vessel which, being basically a hydraulic cyclone, will provide therein that the fiber and fiber bundles in suspension, directed tangentially inward thereof, will be inherently caused to move, once more, the length of the chamber defined in the vessel 57, in a swirling vortex type flow pattern. Since the velocity of the suspension increases inversely with the radius, this means that fibers in a smaller diameter portion of the flow will move past those in a larger diameter portion of the flow. Accordingly there are resultant shear forces which do an excellent job of separating one fiber from another to expose the entire surface of the separate fibers to wetting by the digesting liquid which forms the vehicle for the fiber flow. Accordingly, in the process of this cyclonic movement, in a free vortex flow pattern, the shear forces produced cause a further and inherent separation of the fibers, one from the other, and a continuing and further changing exposure thereof to different portions of the attendant cooking or conditioning liquor. This separating action and exposure will continue to provide further solubilizing and dissipation of the lignin and other materials tending to cling to the fibers and groups of fibers.

As is well known the operation of the vessel such as here designated as the cyclonic digester 57, there will be a vortex flow moving downwardly in the outer layers of the swirling fluid to which will move and in which will be entrained objectionable solids and other non-fibrous elements accompanying the fibers to the separator. This outer or reject portion of the flow will move to and through the outlet 61. Simultaneously, a counterflow of fluid which embodies the acceptable fiber products and attendant fluids in which there is solubilized lignin and other material of which the fibers have been relieved will move upwardly of the separator. This acceptable portion of the flow will exit through the overflow or accepts tube or outlet 60. It is noted that in passage through the digester 57 there is produced a reduc-

tion of the pressure on the materials which exit at 60. This reduction is in the neighborhood of about 5 p.s.i.g. so that the accepts flow is under the influence of a pressure of approximately 145 p.s.i.g.

The overflow tube 60 is sealingly connected with a conduit 62, the remote end of which is sealingly connected to the tangential inlet 63 of a cyclonic digester 64. The digester 64 is identical in form and operation with the digester 57. Therefore, it will be described only in reference to its specific function and not in repetitive detail.

In the case of the digester 57 its underflow or reject outlet 61 is extended by a conduit 65 to the interior of a receptacle defining a chamber 66. The line 65 incorporates a control valve 68 which may be used in a known manner to control the function of the digester 57. It will be seen that the chamber 66 affords a means for deposit of inorganic rejects which are separated from the accepts in the vessel 57. As may be further seen from FIG. 1 of the drawings, there is a similar connection of the rejects outlet of the digester 64 to a receptacle 76, by way of a valve, to conduit 75. Suitable means are diagrammatically shown in connection with both the chambers 66 and 76 to provide for a common and periodic evacuation thereof in a conventional manner. Since the details of the evacuation are not pertinent to an understanding of the invention, they will not be further described.

In the operation of the cyclonic digester 64 and the issuance of accepts therefrom by way of its overflow nozzle 71, there will be a further reduction of pressure on the accepts flow, in the amount of approximately 5 p.s.i.g. in the example illustrated. Therefore, this flowing portion of the pressurized system will have a pressurized environment with the pressure level of approximately 140 p.s.i.g. and a corresponding temperature level in the neighborhood of 361°F.

As will now be apparent, the fibers and fiber bundles will on issuance from the refiner 36 be subjected to successive cyclonic digesting stages, in which stages the fibers are further separated, one from the other, and repeatedly exposed to changing portions of the attendant conditioning or cooking liquor carrying them in a vortex type flow pattern. As described there is a first stage in the vessel 42 in which there is mixing, separation and digesting; a second stage in the centrifugal digester 57; and a third stage in the digester 64. In the example, the fiber products leaving vessel 57 as acceptable materials will have a flow consistency of slightly less than 4 percent and in the chamber of vessel 64 they will be subjected to an identical vortex flow pattern as in the vessel 57. Here, however, as noted previously, the operation is under slightly reduced pressure though in the same pressurized environment. The net effect on the materials moving through the vessel 64 is to even further separate and to condition the fibers and to solubilize material remaining attached thereto. In this third stage cyclonic digesting operation the continuing exposure and complete wetting of the fibers with digesting or cooking liquor in the course of their separation by shear influences produced by the vortex flow pattern results in a maximum removal of coatings and attachments from the fibers. The acceptable conditioned fibrous materials which leave the cyclonic digester 64 are in essentially individual form and under the aforementioned reduced pressure.

It will be self evident that the invention utilizes the fact the velocity in a hydraulic cyclone increases inversely as radius. With a conical reduction at the lower end of any such device, fibers within the vessel are caused to move independently of each other and are thereby constantly changing their position in the conveying liquid to permit the cooking liquor to attack from all surfaces. Lignin is thereby rapidly dissolved without injury to the fibers per se. Of course, in the process of this vortex flow the fibers in the bundles are separated one from the other as the sequential incremental digesting of the bonding lignin occurs.

The accepts leaving the overflow outlet of vessel 64 are passed by way of a connected conduit 77 to the tangential inlet 78 of a vertical digester tube 79. The latter has defined therein a multi-purpose continuous vertical chamber 80.

In the course of delivery from the refiner 36 to the chamber 80 of vessel 79, it will be seen that the fibers have not been subjected to any influences which would tend to abrade or break them but rather have been under conditions which promote rapid solubilizing of lignin. The net result of the described procedure is that the solids content of the flow to the chamber 80 will be significantly less than the 4 percent consistency of the slurry in vessel 42, but the fibers will be of essentially individual form and essentially free of coatings or attachments. Otherwise, the fibers are essentially unmodified as to their basic form in which they left the disc refiner. Thus, there will be a flow of reduced consistency under a pressure of approximately 140 p.s.i.g. and at a temperature of 361°F. entering the chamber 80. As will be seen from FIG. 1 of the drawings, this accepts flow from the cyclonic digester 64 will enter the chamber 80 tangentially to the wall thereof and adjacent its upper end. For this reason, in the upper end of the chamber 80 the fibers will first move again in a swirling vortex type flow.

Looking now to the diagrammatic showing of the vessel 79, it will be seen there are three segments of operation contemplated in this vessel. In the upper portion of the chamber 80 there will be a completion of the digesting process and an extraction of a certain portion of the liquid attendant the fiber products, some of which liquid will be reheated to system temperature of 361°F. and recycled back into the chamber adjacent its top while the remainder of the liquid is returned to the system through line 48 or may, in the alternative, be directed to a chemical recovery system. The net result is to increase the consistency of the flow as it moves downwardly of the chamber 80. In the next lower segment of the chamber 80, from the bottom thereof there will be cycled an upward flow of hot water, entering through conduit 100, at a temperature of 361°F., for example. This counterflow to the fibrous slurry moving downward of the chamber 80 will diffuse through and wash the fibers in transit, the resulting black liquor, if the Kraft process is used, being cycled outwardly from the chamber 80 immediately below its digesting segment. Further, mining nozzles 70 are connected to discharge in the lowermost portion of the chamber 80. These nozzles direct cold water to cool and flush the washed fibers and to assist them in their discharge through the outlet from the vessel 79, which is connected by way of a conduit 81 to the inlet of an inclined drainer 82. In the drainer 82 the fibrous slurry is picked up and guided in a vertically and upwardly inclined

path by a feed screw 83. The screw 83 carries the fibers to the drainer outlet 84. The drainer of the nature described provides that as the fibers are carried upwardly by the screw 83, the attendant liquid including solubilized lignin and amorphous materials is induced by gravity to pass to and exit from a lowermost point of the drainer housing by way of a drain outlet 85. Thus, dependent on the control in the vessel 79 and the drainer 82, the fiber products issued through the outlet 84 of the drainer will have the desired high consistency, at which consistency the fibers will be passed for the first time from the pressurized environment of the invention system by way of a second system sealing rotary valve 86. The latter is of a nature comparable to the rotary valve 18 first described.

Let us look briefly to the diagrammatically illustrated details of the vessel 79. As noted previously, the chamber 80 extends the vertical length of the shell defining vessel 79. At a level between one-fourth to one-third of the way from the top of chamber 80, vessel 79 is circumferentially girdled by a conventional strainer sleeve 87 having a discharge conduit 88 connected to the inlet of a centrifugal pump 89. The discharge from the pump 89 is directed to a heat exchanger 90 way of a conduit 91. Extending through the heat exchanger 90, the conduit 91 connects to a recirculating line 92. The latter discharges back into the upper end of the chamber 80, immediately below the level of the tangential inlet 78. Note further that at a level spaced immediately below the strainer 87 the vessel 79 is girdled by a further strainer sleeve 93. Connected to the latter is a discharge conduit 94 connected to the inlet of a centrifugal pump 95. The discharge from the pump 95 is directed by way of a conduit 96 to a discharge line 97 a branch 98 of which is commonly connected to the conduit 91 and incorporates a control valve 99. Further, spaced substantially below the strainer sleeve 93, there is connected into the chamber 80 a line 100 for delivering a supply of hot water to the chamber. This hot water is so directed to move upwardly of the chamber 80 in a diffusing and washing relation to the downcoming fibers. The mining nozzles 70, previously described, are connected into the vessel 79 to open to the chamber 80 at its lower end.

Accordingly, considering in full the operation of the vessel 79, on inflow to the top thereof of the separated and conditioned fibers issuing from the overflow nozzle 71 of the cyclonic digester 64, the fibers in a slurry of approximately 3 percent will move tangentially of the wall of chamber 80 in a swirling vortex-like flow pattern which is modified as the flow moves downwardly of the chamber. At the level of the strainer sleeve 87 the flow is subjected to the influence of the pump 89 which draws attendant liquid from the flow. A portion of this liquid drawn from the flow will be cycled by the pump 89 through the conduit segment 91 and by way of line segments 98 and 97 to be discharged for recovery or further use. The setting of the valve 99 will determine what portion is to be cycled from the system. The balance of the liquid withdrawn from the flow by the pump 89 will be cycled through the heat exchanger 91 back to the upper portion of the chamber 80 by way of the conduit 92. In this reheating process the cycled liquid is brought to the system temperature of approximately 361°F. at this point. Of course, the strainer sleeve 87 is so designed to inhibit passage therethrough to the pump 89 of any fiber content in the flow and it

may be provided with suitable means to prevent fibers matting over the strainer sleeve. What is achieved in the upper portion of the vessel 79 is an increase of the consistency of the fibers in the flow. Preferably the resulting consistency will be in the neighborhood of 10 percent as contrasted to the 3 percent consistency on entry to the chamber 80. Also, in this upper portion of the chamber 80 there is a completion of the digesting or solubilizing of any lignin or amorphous material which may still remain attached to the fiber elements in the flow. Of course, the setting of the valve 99 may be adjusted to insure whatever consistency is desired.

As the higher consistency flow moves downwardly of the chamber 80, it is met by the upcoming hot water from the delivery line 100. In the course of its counter-flow, as previously described, the hot water will diffuse through the downcoming slurry and wash the fibers, in the process detaching any undesirable particles. At its upper limit of flow the hot water will have the form of the weak black liquor which is caused to exit through the strainer sleeve 93 under the influence of pump 95 to mingle with the black liquor which has been extracted from the system to discharge by way of the conduit segments 98 and 97. As detailed, the fibers are then cooled and influenced to discharge from the chamber 80 at a flowable consistency, in which form the fibers are carried to the drainer. In the drainer there is a controlled relief of attendant liquids to the extent desired to produce the final consistency of the fibers required to issue from the pressurized environment of the invention system.

To summarize, by the practice of the invention raw fibrous materials of wood-like character, in chip or other form, are first subjected to heating in the vessel 10 and such material, relatively free of exterior moisture, is passed in its natural form through the valve 18 to a pressurized environment and within said environment first to the conditioning unit which softens the lignin bond between the fibers. Then in the pressurized environment the raw materials are gently reduced in the double revolving disc refiner 36 under the influence of steam, in the example illustrated under a pressure of 150 p.s.i.g. with a corresponding temperature of approximately 366°F. While these figures are given as a preferred example, the pressure of the system can preferably range between 100 and 150 p.s.i.g. and the temperatures will correspond. In continuance of the system the fibers and fiber bundles with their semi-liquid lignin coating as they issue from the disc refiner 36 are then subjected to a series of spaced cyclonic separating and digesting procedures. The definite change from the natural consistency of the raw material first occurs in the first stage of the digesting procedure which is provided in the vessel 42. Here it is insured that any element of air which has passed the disc refiner is vented to the atmosphere.

In the staged separating and digesting action provided in the vessels 42, 57 and 64 preliminary to the vessel 79, the fibers and fiber bundles are subjected, at time spaced intervals, to a fiber separating vortex flow pattern wherein the fibers are not only separated one from the other but wherein the liquor attending the fibers during their course of flow is constantly changing. This insures that the liquor about the fibers is not saturated with solubilized lignin but can act to take an incremental part of the lignin casing from the fibers. In

this manner there is assured an optimal individualizing of the fibers and a complete as possible solubilizing of any attaching materials. With the completion of the digesting process in the upper portion of the chamber 80 of vessel 79 and with the washing and cooling of the fibers in exiting from the pressurized environment of the invention system there are produced fibers which can be readily treated, if necessary, in any manner desired. There is no lignin attaching or if there is any it is not to a degree that it would affect direct and immediate chemical treatment of the fibers, where the same is required.

Of course, while a particular description of the consistency at various points in the system has been described with reference to black spruce, the consistencies will be governed by the natural moisture content of the raw material employed, the type of chemical cooking or conditioning treatment selected and the end product required.

The function of the system and process of the invention is not only effective but extremely swift. For example, the time lapse from introduction of raw material to the presteamer 10 to the discharge of its fiber content from the pressurized environment need not be much more than ten minutes. As a matter of fact, in the preferred practice of the invention, the total time lapse will be in the neighborhood of 2 to 4 minutes. In respect to the time lapse between refiner 36 and the vessel 79, this may be as little as 24 seconds. The course of treatment in the vessel 79 and the drainer 82 thus dictates the total time for the invention process to operate.

The invention system is significant in that it provides for separation of raw material into individual fibers in a gentle manner, primarily by solubilizing the lignin content in the presence of shear forces in the course of a vortex-type flow. Inherent in this operation is the fact that the digesting or cooking liquor employed will bathe and continuously move over the total surface of each fiber element as it is exposed. Uncoated fibers are clearly produced thereby. Rapidity of digesting is also inherent in the process of the invention in that each cyclonic digesting action will take on the average of 8 to 12 seconds, provision being made for an approximately 5 p.s.i.g. drop in pressure across each cyclonic digesting unit. Of course, depending on the application, the materials to be reduced and the end product desired, there can be two or more cyclonic digesters in series in a manner clearly obvious.

Refinements of the outlined system can be made as follows: For example, the steam vented from the valve 18 may be directed from conduit 29 by way of an appropriate supply line to provide the heating fluid injected in the vessel 10. Thus a steam atmosphere may be provided to flow through the moving chips in the vessel 10 and through the charge thereof in the tube 15 whereby to initially displace air that might accompany the chips. As noted previously, this will minimize the possibility of existing oxygen which might tend to degrade the heated wood in process in the system. Further the black liquor extracted from the slurry flow in the upper portion of the vessel 79 may be directed, as previously described, at least in part, from the conduit 97 to the supply line 48 which delivers liquor to the chamber section 45 of the vessel 42. By the noted refinements, it may be seen that the system may be operated on an extremely economical basis.

Where it is desired to accelerate the conditioning of the pulp fibers in the practice of the invention, conditioning fluid, either in the form of a hot water spray or chemicals will be applied to the fibers and fiber bundles, in a spray form, either at the disc refining surfaces in the housing 39 or as they leave the same in discharge to the vessel 42. By such means there will be a preliminary wetting of the fibers and fiber bundles to commence a solubilizing and conditioning of the fibers in passage to the vortex flow of conditioning fluid in the vessel 42. It is noted that fibers leaving the disc refining surfaces will at this point pick up liquid very readily and this can be of some advantage in the digesting process under certain conditions.

FIG. 4 of the drawings shows a modification of the invention system which provides that drainer 82 is connected to directly receive the discharge from the conduit 77. Under such circumstances, the discharge from the cyclonic digester 64 will be immediately drained or dewatered to produce fibers essentially free of attendant liquid. As illustrated, the resultant fibers are then directed into the top of a hollow vessel defining a vertical chamber 103. The delivery end of a conduit 104 is connected into the upper end of the chamber 103 to inject steam at the system pressure (100 to 150 p.s.i.g.) and corresponding temperature to produce a vapor phase cooking of the digested fibers as they drop through the chamber under the influence of gravity. Adjacent the bottom of chamber 103, a conduit 105 is connected to inject a supply of washing fluid such as provided in the vessel 79. This washing fluid is directed upwardly of the chamber to diffuse through and wash the downwardly moving fibers in a manner and by means similar to that described with reference to the vessel 79. If desired, rather than the washing being accomplished in the chamber 103, the washing may be conventionally accomplished in a separate vessel in series relation to chamber 103 in a manner believed obvious. In either event, the vapor phase cooking and washing will be within the pressurized environment of the invention system.

FIG. 5 shows a further modification of the invention system wherein the conduit 77 is connected to discharge directly to the inlet 111 at the lower end of the underside of an inclined tubular digester vessel 112. The vessel 112 provides therein a longitudinally extended vertically inclined chamber which contains a mid-partition 113, the ends of which terminate short of the ends of the vessel and the body of which is surrounded the length thereof by an endless conveyor including a chain 114. The latter mounts perpendicularly projected conveyor paddles 115. The digester unit 112 in this case contains a bath 116 of conditioning liquid in its lower end. This liquid functions to complete the dissolving and separation from the fibers of the last vestiges, if any, of attached lignin and any other undesirable substances which remain thereon. As may be seen, the level of the digesting or conditioning liquid providing the bath positions above the inlet 111 so the incoming discharge from the cyclonic digester 64 will flow directly into the bath 116 so provided. The incoming fibers are picked up and carried by the paddles 115 which move with the endless chain 114. As the result of this, the fibers are moved first down and around the lower end of the chamber wall and up through the bath 116 on the upper side of the mid-partition. In the process conditioning or digesting is completed.

Above the bath the space 117, which is longitudinally extended on the upper side of the partition 113, provides a pressurized environment as required in the invention system. In this case the pressure is about 140 p.s.i.g. and the temperature about 361°F. Suitable means 118 are connected to insure maintenance of this condition by injection of steam under pressure. As the fibers are carried up from the bath, they are here subjected to successive water sprays schematically shown at 121 and 122. These sprays function to wash the fibers free of residual attachments and free cooking liquor. This wash water, together with the free liquor and attached particles removed thereby from the fibers drains back to and through suitable drains in the mid-partition. As the washed fibers continue upward thereafter, spent liquor is stripped therefrom in the process to also exit through the suitable drains in the mid-partition. As the fibers reach the upper end of the chamber, they are carried around to and down the underside of the partition to outlet 119. From this point they exit from the pressurized system by way of a rotary valve 120 similar in nature and function to valve 86. It may thus be seen that one may simply and effectively complete the cyclic digesting procedure of the invention before leaving the pressurized environment. The system as so provided will again result in optimally conditioned long strong fibers which can be immediately applied to or processed for end product application.

It will be obvious that there can be various arrangements of system elements subsequent to the cyclonic digester 64 and preceding the discharge valve 86 and similar advantageous results can be achieved. As previously noted for certain applications the digester 64 can be eliminated or additional digesters may be added in series thereafter. The arrangement and function of the elements incorporated at this point will depend, of course, on the materials employed and the end products desired.

One further embodiment of the invention of particular advantage is illustrated in FIG. 6 of the drawings. Here, as may be seen, the discharge of accepts from the cyclonic digester 64 by way of the conduit 77 is transmitted directly to the inlet of a tubular cooking vessel 130. As will be self-evident, the vessel 79 and drainer 84 are eliminated in this case. The discharge from the vessel 130 is in turn directed through a pressure sealing rotary valve 86 such as previously described to a washing vessel 131 the discharge from which leaves the described system by way of a further rotary valve 86, as schematically shown. As can be seen, the vessels 130 and 131 are of a nature that they are structured to be similar to the vessel 112 save for minor modifications to suit their particular application in this instance. They each include mid-partitions as provided in the vessel 112 about which is defined a continuous flow path from an inlet thereto to an outlet therefrom. The mid-partition is in each case provided with suitable drain portions which are continuously wiped clean by the inner ends of the material moving paddles carried about the mid-partition on a continuous chain, again in a manner such as illustrated and described with reference to vessel 112 in FIG. 5. More particularly, the fiber accepts discharged in slurry form from the conduit 77 are directed into the underside of the flow path in the inclined tubular vessel 130, adjacent to the lower end of its mid-partition 135. Mounting in conventional manner and driven about the mid-partition 135 is an

endless chain 132 mounting the paddles 133 which move in a wiping relation to the exterior surface of the mid-partition and particularly its drain surface portions. In the course of movement thereof past the inlet of the cooking vessel, as the slurry moves therein from the cyclone digester 64, the paddles will engage and move the fibrous content of the slurry therebetween down about the lower end of the mid-partition, up the upper side thereof and around the top to a point of discharge through an outlet 136 connecting with the flow path to the side thereof below the mid-partition. Means are provided in conjunction with the vessel 130 to maintain therein the system temperature and pressure previously described, particularly corresponding to that in the immediately preceding cyclonic digester. This condition provides for vapor to fill the vessel 130 under the prescribed pressure and temperature and in the course of movement of the fibers by the paddles on the upper side of the mid-partition there is drained therefrom free liquor and, subsequently, spent liquor as the fibers are successively cooked in the process. Of course, the provision of suitable drains in the mid-partition enables the drain liquid to have a controlled minimal level in the vessel 130 and the drained liquid together with the spent liquor removed from the fibers is caused to rapidly exit from the system for disposal in accordance with the needs of the particular installation. Thus, the vessel 130 serves as a device in which the individual, relatively long, high quality fibers which have been gently produced by refining and cyclonic digesting as described are totally cooked. From the vessel 130 the cooked fibers are then directed through the vessel outlet into the washing vessel 131, at the top thereof and adjacent the upper end of its mid-partition. The structural details and function of the vessel 131 and its associated equipment will be generally as set forth in the patent to Eberhardt U.S. Pat. No. 3,111,832 which issued Nov. 26, 1963. Accordingly, since the details per se form no part of the present invention, it suffices to simply state that within the vessel 131 corresponding to the aforementioned patent the fibers which have been cooked are then fully washed and reduced in temperature prior to discharge from the vessel 131 by way of the following pressure sealing valve 86.

It is noted in the system just illustrated that the total of the equipment thereof is within a pressurized environment but the washer is preferably sealed to either end to facilitate a selective change in pressure and temperature which may be required dependent on the nature and character of the fibrous elements which are washed therein. In certain instances, circumstances may dictate that the last valve 86 may not be necessary. This would be due to the fact that there would be no exposure to the atmosphere of the fibers being washed until in fact there is a discharge from the vessel 131. Nevertheless, the maintaining of a seal at the discharge end of the vessel 131 is in most cases preferable as described.

It should be clearly understood that this last described system which includes the basic invention features enables a completely cooked and conditioned fiber of high quality utilizing a minimum of equipment occupying a minimal amount of space. Not only is economy inherent in this complete system but one can produce optimally conditioned fibers of highly desirable length and individual form which can generally be

applied directly to a system for processing the same into end products. It is emphasized that a gentle and economical and relatively complete refining, digesting and cooking system is so provided. Of course, there can be variations in the system well within the scope of the capabilities of those versed in art, once the present disclosure is available.

From the foregoing it will be readily apparent that the present invention achieves a unique system and process having a high degree of versatility and featuring a digesting or conditioning of raw materials as well as a rapid reduction thereof in a manner not heretofore practiced in the art. The net result is in any event a highly useful and improved individualized fiber which has been essentially fully conditioned and made ready for use in a great variety of applications and end products, with or without further treatment. The invention is significant, moreover, in that the elements of the system required enable a minimizing of capital investment for the processing desired.

From the above description it will be apparent that there is thus provided a device of the character described possessing the particular features of advantage before enumerated as desirable, but which obviously is susceptible of modification in its form, proportions, detail construction and arrangement of parts without departing from the principle involved or sacrificing any of its advantages.

While in order to comply with the statute the invention has been described in language more or less specific as to structural features, it is to be understood that the invention is not limited to the specific features shown, but that the means and construction herein disclosed comprise but one of several modes of putting the invention into effect and the invention is therefore claimed in any of its forms or modifications within the legitimate and valid scope of the appended claims.

Having thus described my invention, I claim:

1. A cyclonic digesting process including the steps of subjecting fibers and/or fiber bundles to a vortex flow pattern in each of a series of staged steps which are series related, in a first of which steps the fibers and/or fiber bundles are introduced to a conditioning liquid by providing in respect thereto a tangential inflow of the conditioning liquid which is applied thereto in a vortex flow pattern which picks up, and entrains the fibers and/or fiber bundles, said vortex flow of conditioning liquid being applied to induce repeated separation of the fiber content of the fibers and/or fiber bundles to provide a shifting exposure of the fiber content to said conditioning liquid and in following of said steps the resultant conditioned fibers and/or fiber bundles and accompanying conditioning liquid are subjected to a further vortex flow, influencing the fiber content to successively separate and producing a changing exposure thereof to the conditioning liquid whereby to continue the conditioning of the fiber content and effect a thorough exposure and conditioning of the fibers thereof, producing by said staged steps an end fiber product wherein the fibers have been essentially individually conditioned.

2. A process as in claim 1 characterized by conducting said steps in a pressurized environment.

3. A process as set forth in claim 2 characterized by providing a pressurized operating environment for each of said steps such that operating pressures are relatively reduced from one step to the following.

4. A process as in claim 2 characterized by inhibiting the passage of air with the fibers and/or fiber bundles from the first to the succeeding of said staged steps and directing the fibers and/or fiber bundles and attendant conditioning liquid resulting in the first of said steps to the following of said steps in a relatively non-turbulent flow, and in the following of said steps recreating a vortex flow of the said fibers and/or fiber bundles and the conditioning liquid to further separate the fibers and dissipate and separate therefrom attached inorganic materials and foreign solids while further exposing the fibers to conditioning liquid.

5. A process as in claim 2 characterized by separating inorganic and attached materials from fibers and/or fiber bundles in the course of said staged steps and subjecting the resultant fiber products to a flow of cooking liquor to further the conditioning and digesting process and then draining prior to discharge of the fiber products from said pressurized environment.

6. A process as in claim 1 characterized by at least three said staged steps at spaced intervals wherein said fibers and/or fiber bundles are subjected to a vortex flow pattern in the presence of a digesting or cooking type conditioning liquor and in the course of a continuing flow.

7. A process as set forth in claim 6 characterized by establishing a pressurized environment therefor and in said environment subjecting raw material to reduction to fibers and/or fiber bundles between opposed relatively rotating discs and delivering the said fibers and/or fiber bundles to be directly picked up in a vortex flow of conditioning liquid applied in the first of said steps.

8. A process as in claim 7 characterized by subjecting said fibers and/or fiber bundles to a shower of liquid in passage from said discs to the first vortex flow of conditioning liquid.

9. A process as in claim 7 characterized by gradually reducing the pressure to which the fibers and/or fiber bundles are subjected in said steps.

10. A cyclonic digesting process as in claim 1 characterized by conducting said staged steps in a pressurized environment and subsequent to said staged steps introducing said fibers into a liquid bath in a vessel while maintaining above said bath a pressurized environment substantially corresponding to that in which said staged steps are conducted; and moving said fibers through said bath to digest remaining solids or attachments and then through a vapor path above said bath to cook the fibers prior to their discharge from said pressurized environment.

11. A cyclonic digesting process including the steps of subjecting fibers and/or fiber bundles to a vortex flow pattern in successive staged steps which are series related and in an environment of elevated temperature and pressure maintained by sealing the entrance to and exit from said environment to inhibit the escape therefrom of pressure while delivering said fibers and/or fiber bundles to said environment in the form of raw fibrous material, in said environment subjecting said raw material to reduction to fibers and/or fiber bundles between opposed relatively rotating discs and delivering said fibers and/or fiber bundles to be directly picked up in a vortex flow of conditioning liquid in the first of said digesting steps, by providing in respect thereto a tangential inflow of digesting or cooking liquid, in said first step and following steps exposing the fibers and/or fiber

bundles to said liquid while moving the same in a rotating vortex flow pattern in a manner to influence the fibers to successively separate and effect in the process the thorough exposure and conditioning of the fibers, the subjecting of said fibers and/or fiber bundles to a vortex flow pattern in the presence of the digesting or cooking liquor being provided at spaced intervals and in the course of their continuing flow, there being at least three such intervals.

12. A process as in claim 11 characterized by subjecting said fibers and fiber bundles to a shower of liquid in passage from said discs to said vortex flow of conditioning liquid.

13. A process as in claim 11 characterized by the step of separating inorganic and other attached materials from the fibers and fiber bundles in the course of said staged steps and, subsequent to said staged steps, subjecting the resultant conditioned fiber products to a flow of cooking liquor to further the digestion process and then draining the digested fibers prior to their discharge from the pressurized environment.

14. A process as in claim 11 characterized by draining the fiber products resulting after the said stage steps and cooking them in a vapor phase environment prior to discharge from said environment.

15. A process as in claim 11 characterized by gradually reducing the pressure to which the fibers and/or fiber bundles are subjected in the course of effecting said staged steps.

16. A process as set forth in claim 15 characterized by thereafter cooking, draining and washing the resultant fiber products prior to discharge from said environment.

17. Apparatus providing a cyclonic digesting system including means defining a plurality of chambers connected in series relation, at least one of said chambers having an inlet for an infeed thereto of fibers and/or fiber bundles, and attendant liquids if any, means for separately directing a conditioning liquid into said one chamber, at least said means for separately directing the conditioning liquid into said one chamber and the configuration of said one chamber being arranged for tangential inflow of the conditioning liquid so that within said one chamber said conditioning liquid will move in a vortex type flow receiving, entraining and moving the fibers and/or fiber bundles entering said one chamber in a manner to maintain the same in a continuous fiber separating vortex flow pattern to continuously and progressively expose the fibers to the conditioning liquid for continuing treatment thereof, and means defining connections between said chambers providing for a continuing flow of the conditioning liquid and entrained fibers and/or fiber bundles into a following of said series related chambers which provides means for immediately inducing a further vortex flow pattern thereof of a nature to repeat and continue the fiber separating action as in said one chamber and to progressively and further expose the fiber contents to the conditioning liquid, said apparatus producing thereby a staged cyclonic digesting and conditioning action on the fiber content of said fibers and fiber bundles.

18. Apparatus as in claim 17 characterized by means for sealing and maintaining a pressurized environment within said chambers of said cyclonic digesting system while accommodating the movement of fibers and/or fiber bundles into and from said system.

19. Apparatus as in claim 18 characterized by said connections between said chambers providing for direct and continuing flow from one to the other of said chambers which is relatively unobstructed.

20. Apparatus as in claim 17 characterized by said one chamber being a first said chamber in said series and said means for directing conditioning liquid into said one chamber being positioned relative said inlet to provide that the incoming fibers and/or fiber bundles will drop into the vortex produced by said conditioning liquid and be so entrained.

21. Apparatus as in claim 20 characterized by means in said one chamber operative to break up the vortex flow pattern of said fibers and/or fiber bundles and conditioning liquid in the exit thereof from said one chamber to the means defining the connection thereof to the following chamber.

22. Apparatus as in claim 17 characterized by said chambers and the connection therebetween providing for a staged pressure drop within said series of chambers.

23. Apparatus as in claim 17 characterized by at least two said chambers following said one chamber in said series, said two chambers each having means defining an accepts outlet, means defining a rejects outlet and means defining a tangential inlet, and a means defining the connection between the two said chambers connecting the accepts outlet of one to the tangential inlet of the following of said two chambers.

24. Apparatus as in claim 17 characterized by a double revolving disc definer having a discharge outlet opening to and connected with said one chamber, said refiner including means to reduce fibrous material to said fibers and/or fiber bundles and to deliver said fibers and/or fiber bundles to said one chamber and means in connection with said one chamber to introduce said conditioning liquid into said one chamber by way of said directing means in an area of said chamber spaced from said inlet to first pick up and embody said fibers and/or fiber bundles in said vortex flow in a manner to separate, expose and wet the fibers with said conditioning liquid, the other of said chambers in series being arranged to subject said fibers and/or fiber bundles resulting and said conditioning liquid to further vortex flow to produce further separation of the fibers and/or fiber bundles and further shifting exposure thereof to conditioning liquid in movement thereof therethrough.

25. Apparatus as set forth in claim 24 characterized by means sealing the elements of said system to produce therein a pressurized environment and means for receiving, washing and cooling the fiber products delivered from the last of said chambers in series prior to discharge from said environment, and said chambers being so related to provide for differential pressure therein.

26. Apparatus as set forth in claim 24 characterized by means in connection with and preceding said disc refiner for receiving, conveying and bringing fragments of raw fibrous material up to a predetermined temperature to soften bonds between their fibers, valve means preceding said disc refiner for passing said fragments while forming a pressure seal to the inlet side of said refiner and further valve means for discharging the conditioned fiber material delivered from said chambers in series and maintaining at the same time a pressure seal on the discharge side of said chambers whereby, in op-

eration thereof, said disc refiner and said chambers may be maintained under conditions of elevated temperature and pressure, the discs of said refiner being arranged to act on and reduce the fragments of said fibrous material to fibers and fiber bundles, and means interconnecting said chambers providing for a staged reduction of pressure from one to another thereof.

27. Apparatus as in claim 26 characterized by means for applying a conditioning liquid to wet the surface of exposed fibers in said disc refiner and said refiner being in direct open communication with the interior of said one chamber for discharge of wetted fibers and/or fiber bundles to said one chamber.

28. A cyclonic digesting system as in claim 27 characterized by digester means connecting with and receiving the discharge from said chambers having in connection therewith means to influence a completion of the conditioning of the fibers and to increase the consistency of their flow in the course of discharge.

29. Apparatus as in claim 17 characterized by means providing in said chambers a pressurized environment and means in connection with said chambers having therein a corresponding pressurized environment and arranged to receive and complete the conditioning of the fiber products which issue therefrom in a fluid flow and to both drain and cook the fibers prior to discharge from said pressurized environment.

30. Apparatus as in claim 29 characterized by said last named means including an inclined longitudinally extending chamber in the lower end of which is accommodated a bath of conditioning liquid arranged to directly receive the discharge from the last of said chambers for movement of the resultant fibers through said bath and through a vapor phase thereabove created by means connected to produce said vapor phase as a cooking and liquid stripping environment.

31. A cyclonic digesting system including a plurality of chambers in series relation, means for directing an infeed of fibers and/or fiber bundles and attendant liquids, if any, inwardly of each of said chambers, means for directing discharge from one to the following of said chambers to provide for infeed thereof to the following of said chambers, at least one of said chambers having infeed means in connection therewith to direct a pressured inflow of conditioning liquid, at least a portion of said liquid infeed directing means and the configuration of the related chamber being arranged for tangential inflow of the conditioning liquid so that within any such related chamber said fibers and/or fiber bundles and the said liquid will move in a rotating vortex producing flow effecting a separation of fibers from fibers and thorough exposure and conditioning thereof by attendant liquid, a double disc refiner having a discharge outlet open to and connected with a first of said chambers, said refiner including means to reduce fibrous material to said fibers and fiber bundles and to deliver said fibers and/or fiber bundles to said first chamber and means in connection with said first chamber for introducing said conditioning liquid in a vortex type flow to first pick up and embody said fibers and/or fiber bundles in said vortex flow in a manner to separate, expose and wet the fibers and the other of said chambers in series being arranged to subject said fibers and/or fiber bundles resulting to further vortex flow producing an inherent further separation of fibers and further exposure to conditioning liquid in movement therethrough.

32. Apparatus as set forth in claim 31 characterized by said chambers being so arranged to provide for differential pressure in at least a portion thereof arranged in series.

33. Apparatus as set forth in claim 32 characterized by means sealing the elements thereof to produce therein a pressurized environment and means for receiving, washing and cooling the fiber products delivered from the last of said chambers in series prior to discharge from said environment.

34. Apparatus as set forth in claim 31 characterized by means in connection with and preceding said disc refiner for receiving, conveying and bringing fragments of raw fibrous material up to a predetermined temperature to soften the bonds between their fibers, there being valve means preceding said disc refiner for passing said fragments while forming a pressure seal to the inlet side of said refiner and further valve means for discharging the conditioned fibers delivered from said chambers in series and maintaining at the same time a pressure seal on the discharge side of said chambers whereby, in operation thereof, said disc refiner and said chambers may be maintained under conditions of elevated temperature and pressure, the discs of said refiner being operable to act on and reduce the fragments

to said fibers and fiber bundles.

35. Apparatus as set forth in claim 34 characterized by means interconnecting said chambers to provide for a staged reduction of pressure from one to another thereof.

36. Apparatus as in claim 34 characterized by means for applying a conditioning liquid to wet the surface of exposed fibers in said disc refiner, said refiner being in direct open communication with the interior of the first said chamber for discharge of the wetted fibers to said first chamber and said first chamber having means for maintaining a level of conditioning liquid therein defining an open space through which the fibers and/or fiber bundles discharged from said double disc refiner will fall to said level and there being means in connection with said space to provide for a metered bleed of fluid including air from said first chamber.

37. A cyclone digesting system as in claim 36 characterized by digester means connecting with and receiving the discharge from said chambers having in connection therewith means to influence a completion of the conditioning of the fibers and to increase the consistency of their flow in the course of discharge.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,833,461 Dated September 3, 1974

Inventor(s) Maurice D. Woodruff

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

Col. 7, line 53, -- in -- is inserted following "known".

Col. 10, line 24, -- by -- is inserted to follow "90".

Col. 17, line 61 (Claim 11, line 10), "budnles" has
been amended to read -- bundles --.

Signed and sealed this 4th day of February 1975.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents