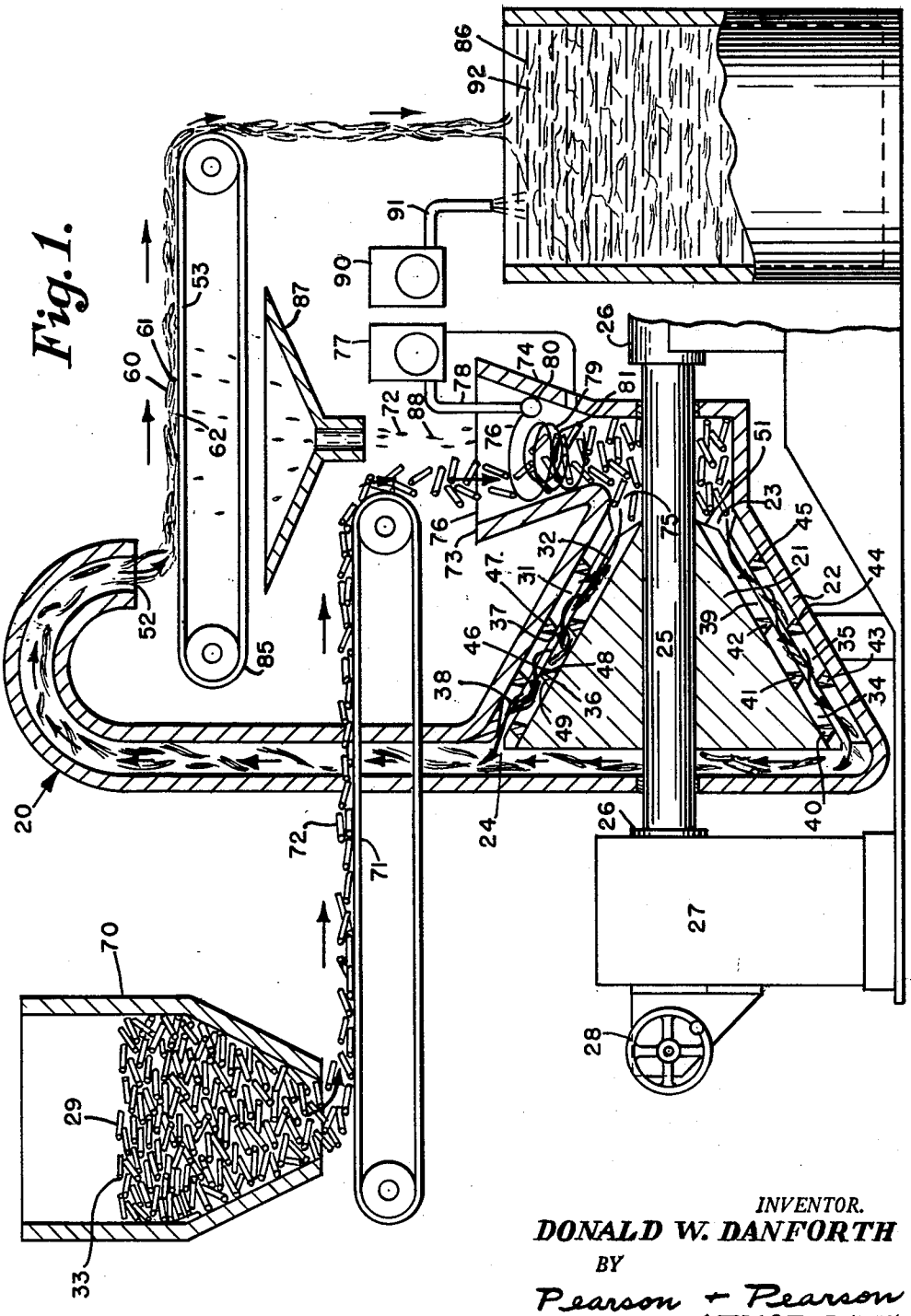
Sept. 15, 1964 D. W. DANFORTH 3,148,839

METHOD OF PROCESSING PAPER STOCK

Filed Aug. 29, 1960 2 Sheets-Sheet 1

Fig. 1.



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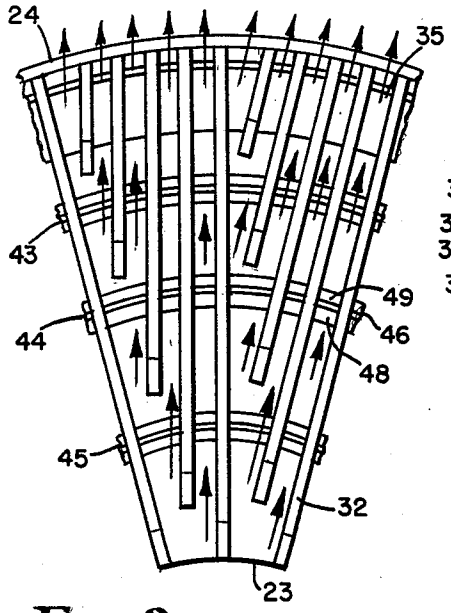

Fig. 2.

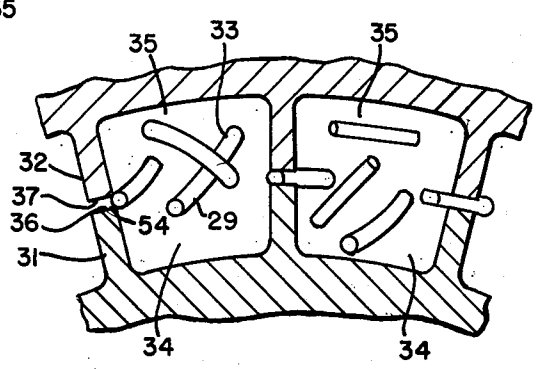

Fig. 3.

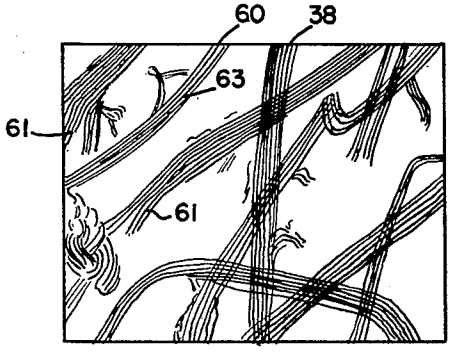

Fig. 5.

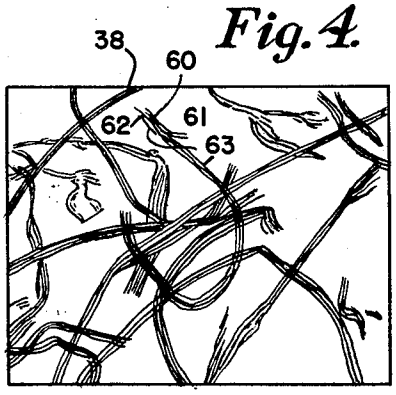

Fig. 4.

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METHOD OF PROCESSING PAPER STOCK

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Filed Aug. 29, 1960, Ser. No. 52,413
11 Claims. (Cl. 241—21)

This invention relates to an improved method for treating raw material having extreme dewatering and plugging characteristics to make the material usable in paper making.

In the paper making art, rotary refiners of the disc or truncated cone type have long been used to place paper stock material in condition for use in a paper making machine. It has been customary to mix the raw material with liquid, in various preliminary processes, and to direct the resulting paper stock through an extensive piping system into the refiner. The paper stock has been moved through the refiner at relatively low velocity and relatively high consistency with sufficient dwell in the refiner to eliminate bundles of fibres and otherwise produce a consistent and homogeneous paper stock. Such refiners have a pumping action, due to the rotation of the parts and operate under pressure in a closed system. By suitable control of the inlet valves, outlet valves, rotor speed and blade clearance the dwell of the stock in the refiner can be increased or decreased and the degree of refining treatment produced on the stock can be varied.

Certain raw materials such as synthetic fibres of uniform or random dimensions, bits of leather, cotton comber stock or wood shavings, however, have heretofore been difficult to condition for paper making because of their extreme dewatering and plugging characteristics. In conventional paper stock systems and in conventional refiners such raw material tends to bridge across any narrow channels, accumulate against any dams or sharp turns, plug up any narrow openings and settle in any low velocity zones, thereby requiring a complete shutdown while the system, or refiner, is opened up and the obstruction removed.

The principal object of this invention is to provide a method for treating material which tends to plug and dewater, in a rotary refiner, by maintaining the material in dry state until just before it is carried through the refiner at high velocity and at low consistency.

Another object of the invention is to provide a method for treating synthetic fibres to make the fibres suitable for uniform felting in subsequent paper making processes.

A further object of the invention is to provide a method for converting staple acrilic fibres into a condition suitable for paper making purposes with the fibres shortened in length, fibrillated and ruptured in such a way as to simulate the appearance of hydrated natural fibres.

Still another object of the invention is to provide a method for fibrillating staple synthetic fibres in spite of the dewatering, clinging and plugging characteristics of such fibres by forming a low consistency mixture thereof directly at the inlet of a rotary refiner, passing the mixture in a sinuous radial and longitudinal path at high velocity through the refiner and rolling and squeezing the fibres as they pass through the refiner.

A still further object of the invention is to provide a method for fibrillating synthetic fibres in which the fibres are flushed at high velocity along an unobstructed longitudinal path, with substantially no restriction, or impedance, of flow and in a liquid carrier of considerable volume while being subjected to lateral rolling and squeezing forces.

Other objects and advantages of the invention will be apparent from the claims, the description of the drawings and from the drawings in which—

FIG. 1 is a diagrammatic side view showing the various steps for accomplishing the method of the invention.

FIG. 2 is an enlarged diagrammatic plan view showing the step of guiding the fibrous mixture from the inlet to the outlet of the refiner without constricting the flow with unduly restricted passages.

FIG. 3 is a diagrammatic end view showing the rolling and squeezing step for fibrillating and shortening synthetic fibres advancing through the refiner.

FIG. 4 is a diagrammatic view portraying the appearance in a micro photograph of synthetic fibres which have been treated in accordance with the invention, and

FIG. 5 is a view similar to FIG. 4, but further enlarged to show the fibrillation of the fibre bodies as well as of the tips in the method of the invention.

As shown in FIG. 1 the method of this invention is preferably accomplished in a truncated, conical, rotary refiner of a well known type such as the refiner 20. While disk refiners, and Jordan engines can be used, it is preferred that the refiner 20 be of the relatively short, relatively steeply inclined type known in the trade as a "Claflin." The refiner 20 includes the usual rotor, or plug 21, the usual stator, or shell 22, the stock inlet 23 at the small end, the stock outlet 24 at the large end and the plug shaft 25. Conventionally the plug shaft is mounted in slidable bearings 26 and rotated at high speed by the motor 27, there being a suitable hand wheel, or automatic device, 28 to advance the plug into the shell and control the clearance between the plug knives, or bars, 31 and the shell knives, or bars 32.

It will be understood that the plug and shell knives of a conventional Jordan are spaced apart to form axially extending channels therebetween so that it is theoretically possible for fibre bundles in the stock to pass the full length of the refiner along a single channel without entering between the knives for treatment. Usually the knives in a Jordan shell are bent to form an angular channel and there have been various proposals for barriers and dams between the plug knives or shell knives to assure that the stock is treated before it leaves the refiner. For example, in U.S. Patent No. 2,921,749 to Brink et al. of January 19, 1960, a plurality of staggered dams are provided to increase the dwell of the stock in the engine and to urge the stock back and forth between the shell and the plug. Such dams and in fact any barriers or guides which increase dwell or stand in the path of the stock have been found to be disadvantageous with material which has plugging, clinging or dewatering characteristics.

The method of this invention seeks to make possible the treatment of such material in a rotary refiner without the wadding or packing of the material and without the necessity for shutting down the equipment to open the system and thoroughly clean the same. It has been found that such material can be used in paper making if liquid is mixed with the dry material and the mixture immediately passed at high velocity through a refiner, while at low consistency, the refiner fibrillating and discharging the mixture before the material has an opportunity to plug. Once the material has received this quick pass through the refiner, its plugging and dewatering characteristics are eliminated and thereafter it can be handled in the same manner as conventional paper stock.

As explained above wood shavings, leather and cotton comber stock are examples of materials which cannot be processed by conventional refining methods because of their extreme dewatering characteristics. The principal material, for which the method of the invention is particularly adapted is synthetic staple fibres such as rayon, nylon and the like. These synthetic fibres are usually monofilaments of uniform diameter, cut into uniform lengths and smooth on the exterior so that they not only

plug and cling when immersed in water, but do not felt properly in a paper machine. To illustrate the method of the invention, synthetic staple acrylic fibres in dry state are shown at 33 to typify materials 29 having extreme dewatering, plugging and clinging characteristics.

The rotary refiner 20, as thus far described is conventional, but it has been modified in a number of respects to carry out the critical steps for successfully processing the material 29. The channels 34 between each adjacent pair of plug knives 31 and the channels 35 between each pair of shell knives 32 cannot be unduly narrow because material of this type will form a bridge across narrow passages, and the machine must be opened to remove the resulting plug or wad. The channels 34 and 35 are, therefore, of predetermined width, height and cross sectional area in relation to the maximum length of the fibres 33 in the material 29 to prevent such plugging. For example, if the synthetic staple fibres 33 are substantially uniformly about one inch in lingth the channels 34 and 35 are at least one inch in width and each channel is at least one half inch in depth. While certain of the knives 31 and 32 may extend axially in a straight line from the inlet end to the outlet end, most of the knives are straight but angularly offset from the axis, but regardless of the angular offset of the knives, the channels therebetween are always of a predetermined width relative to the length of the fibres being treated.

Thus one step of the process, i.e. the guiding of the fibres 33 along an unobstructed, longitudinal path through the refiner 20 with no possibility of bridging, packing or wadding, is accomplished.

It would be useless to pass the material 29 straight through refiner 20 along one of the channels 34 or 35 with the fibres not being subjected to lateral passage and treatment between the working surfaces 36 and 37 of the knives 31 and 32. Similarly, if upstanding, staggered dams such as disclosed in the above mentioned U.S. Patent 2,921,749 were provided in the channels 34 and 35, the fibres 33 would pile up at the dams and create packs, clumps and wads. When such staggered dams in the plug and shell rotate to a position opposite each other, a closed pocket is temporarily formed to cause dwell and dewatering of the mixture 38 containing the fibres 33. A critical step of the method of the invention, therefore, is to guide the mixture 38 in a sinuous path between the channels 34 and the channels 35 to positively and repeatedly traverse the working faces of the blades without in any way obstructing flow, causing dwell or creating closed pockets in the channels. This step is accomplished by the provision of a plurality of circumferentially extending rings of tapered deflectors, the successive rings being designated 40, 41, 42, 43, 44 and 45. The individual deflectors such as 46, in each ring are in the same lateral plane as the other deflectors of the ring, and a deflector 46 of one ring such as 41 never overlies a deflector 47 of another ring such as 42 during rotation of the rotor, or plug, 21. The rings such as 40 and 41 are so spaced longitudinally that the rotor 21 can be advanced by the control 28 to adjust the clearance between the working faces 36 and 37, and to compensate for knife wear without at any time restricting the passage such as 39, between adjacent rings to a width less than the maximum length of fibres 33. The passages 39 between adjacent rings are relatively large near the inlet 23 and are progressively smaller toward the outlet 24 because the fibres 33 become progressively fibrillated and less likely to dewater and plug as they advance through the refiner 20. Each deflector 46 or 47 includes an inclined forward face 48, and an inclined rearward face 49, to smoothly guide the mixture 38 along a sinuous path without trapping fibres and each deflector is preferably formed of a material softer than that of the knives whereby it will not create grooves in the knives of the opposite member.

Unlike conventional refiners, which are pressurized and form part of closed stock systems, in the method of this invention the refiner 20 is preferably open at the inlet end 51 and at the outlet end 52. It is a critical step in the method to advance the mixture 38 at high velocity and low impedence through the refiner with no back pressure and no induced dwell. Because of centrifugal force, disc and truncated cone refiners act as high speed pumps which exert suction at the inlet end 51 and impart considerable velocity to the stock at the outlet end 52. If the outlet 25 leads to a pressurized environment, back pressure slows the stock velocity but in this invention the stock is discharged into an atmospheric environment at 52 onto an endless conveyor 53. Thus the step of advancing the stock through the refiner at unusually high velocity is accomplished by not in any way reducing the pumping action of the refiner and not in any way restricting the effluent discharge stream from the refiner. The term "high velocity" is used herein to mean low, or substantially zero, impedence to longitudinal travel. Thus if 20 gallons per minute are fed to open end 51, the mixture 38 will be flushed and sucked at high speed into the small end of the refiner and discharged from the open end 52 at 20 gallons per minute.

In the treatment of synthetic staple fibres, the clearance between the working faces 36 and 37 is also critical. If the faces 36 and 37 are too close, excessive cutting will result, and if too greatly spaced, an insufficient treatment will result. To properly fibrillate the fibres 33 for successful use in paper making it has been found that the clearance at 54 between the faces 36 and 37 should be slightly less than the diameter of the fibres 33. By use of the control 28, the rotor 21 is thus positioned axially within the stator 22 to provide such clearance and the predetermined clearance is maintained, in a well known manner as the knives wear down. When the clearance is so established, individual fibres are able to partly enter the space between the knives, whereupon they are rolled and squeezed before they are deposited in the next adjacent channel. This action also tends to break or shear some of the fibres into non uniform shorter lengths while fibrillating and partially crushing the fibres to the condition shown in FIGURES 4 and 5. These views are taken from micro-photographs of actual fibres passed through the method of the invention and it should be noted that each processed fibre 60 is frayed at the tips 61 and 62, split along the body portion 63 and otherwise converted to the appearance and characteristics of natural fibres conventionally used in paper making. The predetermined clearance established in refiner 20 when processing man made fibres 33 will depend on the denier, or diameter of the fibres. Preferably the clearance is about one or two thousandths of an inch less than the maximum diameter of the unprocessed fibres to secure satisfactory fibrillation.

In processing materials similar to the fibres 33, it has been found that the mixing of the material with liquid such as water in the usual beaters, stock chests, pipe lines, etc., simply creates an unwieldy, wet clump of tangled fibres which plugs the passages in the system. It has, therefore, been unusable in conventional systems and unused for felting into paper. In the method of this invention, the synthetic staple fibres 33, or any similar material with dewatering characteristics, it is critical that the fibres be retained in dry state and formed into a low consistency mixture 38 just before they enter the refiner 20. The dry fibres 33 are conveniently fed from a hopper 70, to an endless conveyor 71 which continuously feeds a stream 72 of the dry fibres 33 into an open hopper 73 at, and leading into, the refiner inlet 23. The hopper 73 is truncated conical in shape with the mouth 76 open to the atmosphere, a funnel-like body 74 and a lower opening 75 for directing the fibres 33 into the refiner. A continuous supply of liquid 76, such as water, is fed from a suitable tank 77 by the pipe 78 into the hopper 73, in a relatively large volume stream 79 as compared to the stream 72 to form a low consistency mixture closely in

advance of the working surfaces and at, or proximate, the inlet of the refiner **20**. Preferably the consistency of the mixture **38** entering the inlet **23** is about one percent to provide a substantial liquid vehicle or carrier for the dry fibres **33**. As shown in FIG. 1 the liquid supply pipe **78** preferably terminates in a horizontally and circumferentially directed tip **80**, and the liquid is discharged at a volume of about twenty gallons per minute to coil downwardly around the interior of the conical hopper in the manner of a dentist's bowl but at high speed. A liquid funnel shaped configuration **81** is thus achieved which has the submergence effect of a whirlpool or a vortex but without unduly soaking the material before it is sucked or drawn into the refiner.

As shown diagrammatically in FIG. 1 the low consistency mixture **38** after discharge from the outlet end **52**, falls on the endless conveyor **85** which carries the processed fibres **60** into a storage vat **86**. The excess liquid is collected in the pan **87** and may also be permitted to fall in a stream **88** into the hopper **73**.

The vat **86** is supplied with water from the tank **90** through pipe **91** whereby a mixture **92** of any desired consistency may be formed. The fibres **60** in the mixture **92** may be readily and easily processed further or felted into paper and no longer possess the extreme dewatering and plugging characteristics of the original fibres **33**.

In FIG. 2 the pattern of the knives **32** on stator **22** is illustrated to show the wide channels, the angular offset of certain knives and the fact that there are no constricted passages in the pattern. The knives **31** of the rotor **21** define a similar pattern devoid of closed pockets or narrowed passages and a similar pattern may be used in a Jordan engine or in a disc refiner.

The plug and shell linings described herein are the subject of my co-pending patent application, Serial No. 52,412 filed August 29, 1960, and entitled Apparatus for Refining Paper Stock because they are useful in the refining of any paper stock material.

I claim:

1. A continuous process for treating fibrous materials of the type having dewatering and plugging characteristics in a truncated conical rotary refiner, said refiner having an inlet end, an outlet end, rotor blades and channels, stator blades and channels and opposed, planar, working faces on said blades, said process comprises the steps of continuously feeding a supply of liquid to proximate the inlet end of said refiner; continuously feeding a supply of said material, in dry condition, to proximate the inlet end of said refiner; forming a low consistency mixture of said material and said liquid at the inlet end of said refiner, just in advance of the working faces of said blades and immediately advancing said low consistency mixture at high velocity from the inlet end of said refiner to the outlet end thereof; deflecting said mixture in a sinuous, unobstructed, path, back and forth between the rotor blade channels and the stator blade channels of said refiner to positively and repeatedly traverse said working faces while advancing said mixture therethrough; rolling and squeezing the fibres of said material repeatedly between the working faces of the said rotor and stator blades of said refiner while advancing said mixture therethrough and discharging said mixture from said refiner into an atmospheric environment.

2. A method as specified in claim 1 wherein said liquid feeding step includes the step of directing a stream of said liquid in a convergent, helical path defining an open funnel leading into the inlet of said refiner and wherein said material feeding step includes the step of depositing said material into the open funnel defined by said stream to flush with said stream into the inlet of said refiner.

3. A method as specified in claim 1 wherein the step of advancing said mixture at high velocity through said refiner includes the step of drawing said mixture at high velocity into said refiner.

4. A method as specified in claim 1 wherein said deflecting step includes the step of channeling said mixture along passages at least equal in minimum cross sectional dimensions to the length of the longest fibres in said mixture.

5. A method as specified in claim 1 wherein said rolling and squeezing step includes the step of maintaining the clearance between the working faces of the opposed blades of said refiner at slightly less than the maximum diameter of the fibres in said mixture.

6. A continuous process for treating fibrous materials, of the type having dewatering and plugging characteristics, in a truncated conical refiner having a shell, an axially movable plug, an inlet and opposed working faces on the plug and shell blades, said process comprising the steps of continuously forming a whirling, funnel-like stream of liquid proximate the inlet of said refiner; continuously introducing a stream of said material in dry state into said funnel-like liquid stream, proximate said inlet closely in advance of said working surfaces; continuously flushing the resulting mixture of liquid and material through said inlet into said refiner, substantially simultaneously with the admixture thereof; continuously advancing said mixture through said refiner at high velocity; positively deflecting said mixture into a sinuous path between the refiner plug and shell to repeatedly traverse said working faces during its high velocity passage therethrough; fibrillating the fibres in said mixture while said mixture advances at high velocity along said sinuous path through said refiner and then discharging said mixture from said refiner into an atmospheric environment.

7. A continuous process for fibrillating synthetic fibres, of uniform diameter, in a rotary refiner having an inlet, an outlet and working surfaces between the blades of the rotor and stator thereof, said process comprising the steps of directing a stream of liquid into a vortical path proximate, and leading directly into the inlet of said refiner; introducing a stream of said fibres in dry state into said vortical path, proximate said inlet, and just in advance of said working surfaces, to form a mixture of low consistency; immediately advancing said low consistency mixture through said inlet, and through said rotary refiner at high velocity while deflecting said mixture into a sinuous path, repeatedly crossing the working surfaces between the rotor and stator of said refiner while rolling each fibre in said mixture on its longitudinal axis between the working surfaces of the blades of said rotor and stator and then discharging said low consistency mixture from said outlet into an atmospheric environment, said steps being performed in the absence of restriction, constriction or impedance of flow of said mixture through said refiner.

8. A process as specified in claim 7 wherein said deflecting step includes the step of maintaining the cross section of said sinuous path at predetermined minimum dimensions established by the maximum length of the fibres in said mixture to avoid bridging, packing or wadding of the fibres therein.

9. A process as specified in claim 7 wherein said rolling step includes the steps of squeezing each said fibre between said working surfaces and maintaining the clearance between said working surfaces at a distance slightly less than the said uniform diameter of said fibres.

10. A process for treating materials in a rotary refiner having an inlet, an outlet and working surfaces on a rotor and stator establishing a path therethrough which comprises the steps of introducing a uniform stream of said material, in dry state, into a liquid vehicle just in advance of said working surfaces and proximate the inlet of said refiner to form a low consistency mixture; substantially simultaneously flushing said mixture into said refiner; then immediately advancing said mixture at high velocity through said refiner along said path and positively deflecting said mixture sinuously back and forth between the rotor and stator of said refiner and repeatedly across said working surfaces for treating said material along

said path from a lateral direction only and then discharging said mixture from said refiner into an atmospheric environment.

11. A process for treating dry fibrous materials of the type having dewatering and plugging characteristics in a rotary refiner having an inlet, an outlet and relatively rotating working surfaces, said process comprising the steps of continuously mixing a relatively small volume of said dry material with a relatively large volume of liquid, closely in advance of said inlet and said working surfaces to form a mixture with a consistency of about one percent; then continuously and immediately, flushing said mixture into said inlet, through said refiner and out of said outlet at high velocity and without substantially restricting the flow thereof and while said mixture is advancing through said refiner, positively and repeatedly deflecting the same back and forth across said working surfaces for treatment without substantially reducing said velocity or restricting, constricting or impeding the flow thereof through said refiner.

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