

July 25, 1950

H. S. HILL ET AL

2,516,384

MECHANICALLY CURLING CELLULOSE FIBERS

Filed Nov. 25, 1944

3 Sheets-Sheet 1

Fig. 1.

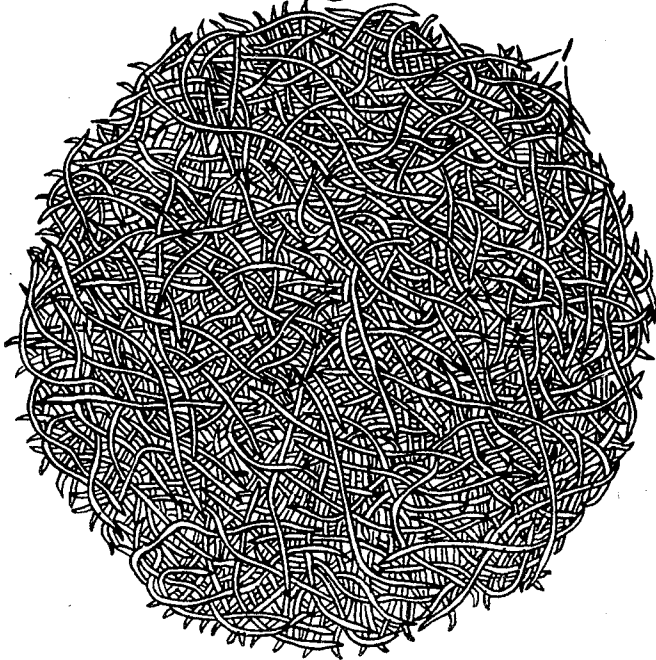


Fig. 2.

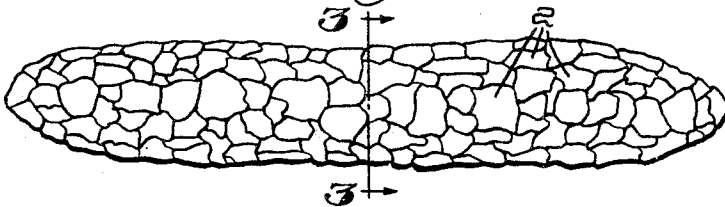


Fig. 3.



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3 Sheets-Sheet 2

Fig. 4.

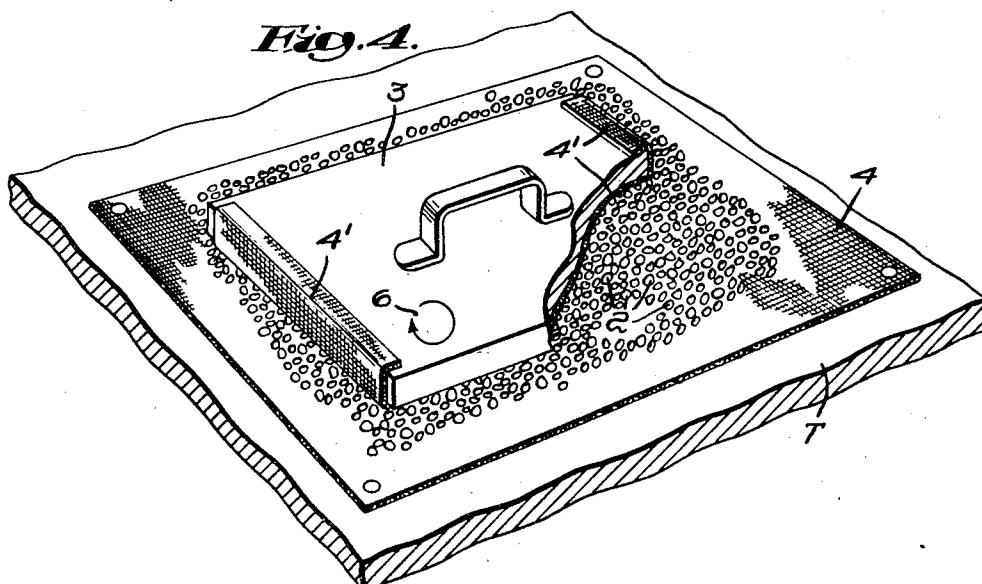
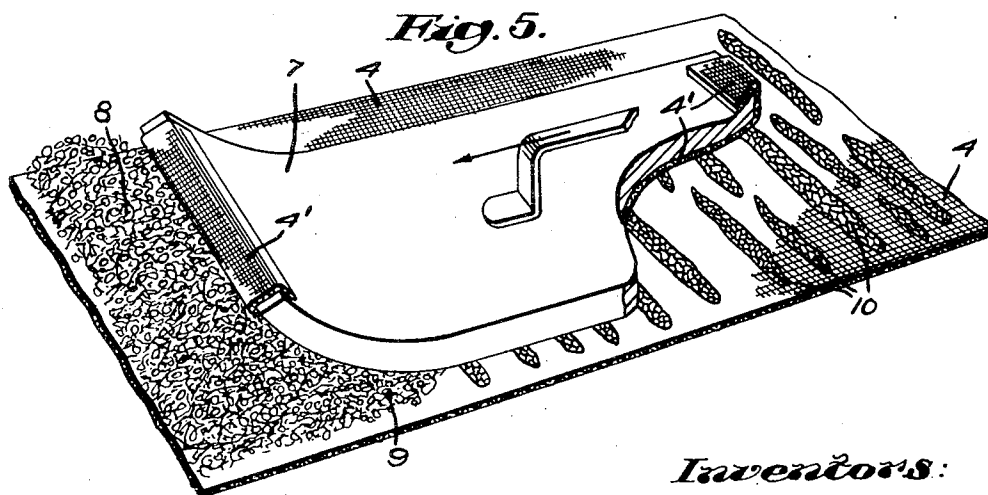


Fig. 5.



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3 Sheets-Sheet 3

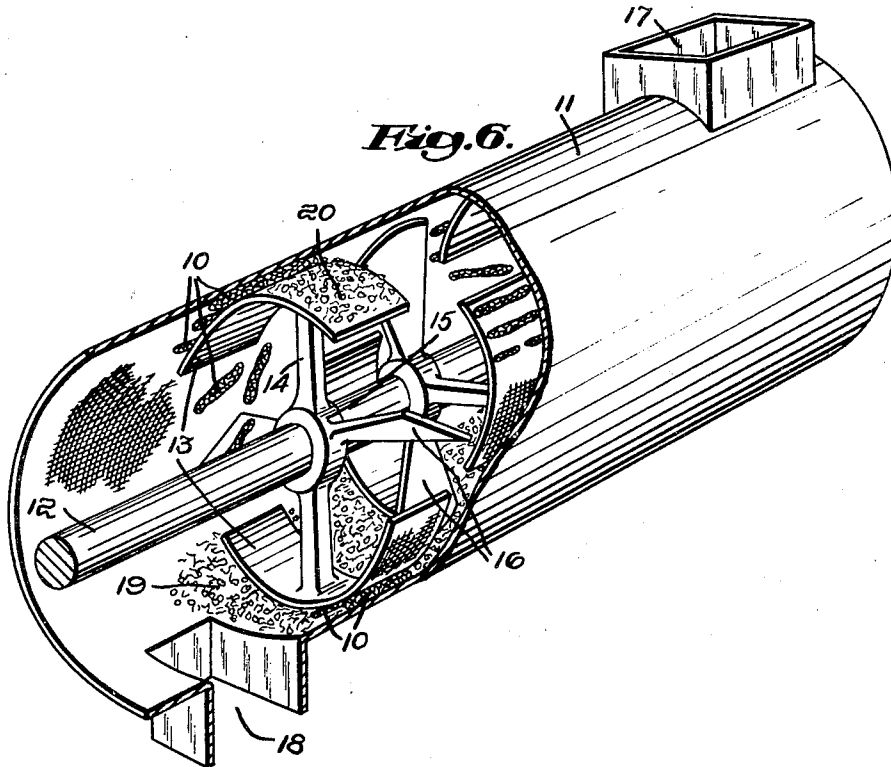
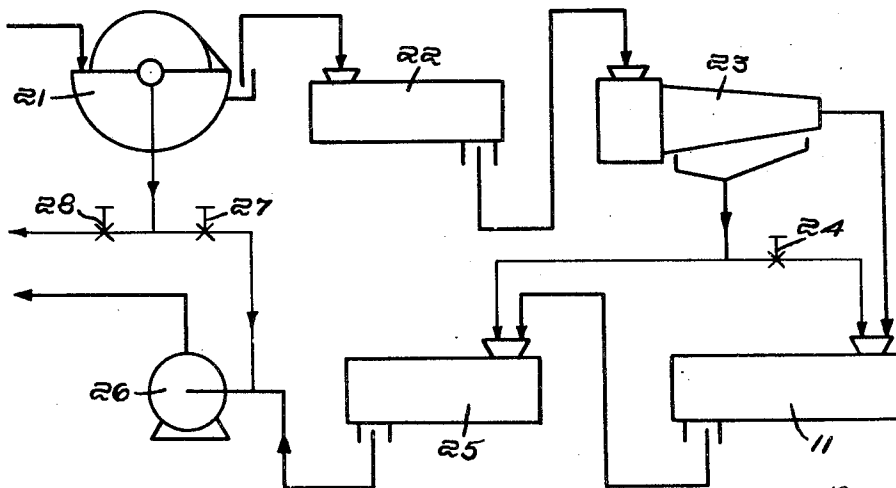


Fig. 7.



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UNITED STATES PATENT OFFICE

2,516,384

MECHANICALLY CURLING CELLULOSE
FIBERSHarold Sanford Hill, Kenogami, Quebec, and
Joseph Edwards, Riverbend, Quebec, CanadaApplication November 25, 1944, Serial No. 565,128
In Canada January 15, 1942

6 Claims. (Cl. 92-20)

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The present invention relates to the mechanical processing of wood pulp to produce useful modifications of its properties, and is a continuation-in-part of our prior application Serial No. 429,948, filed February 7, 1942, now abandoned.

The particular object of the invention is to provide a simple and inexpensive mechanical method of controllably effecting important modifications of the properties of a given wood pulp with little or no decrease in the freeness property and often with an increase in freeness.

A further object of the invention is to provide a particularly effective method of liberating the individual fibres from such shives or fibre bundles as may be present in the pulp being treated.

A still further object of the invention is to provide for the first time a commercial method of producing high-yield, high-freeness pulp which is essentially free of shives or fibre bundles.

Another object of the invention is to provide a particularly effective method of re-pulping paper stock to its individual fibres without the usual production of additional fibre debris and without sacrifice of freeness.

Still another object of the invention is to provide a particularly effective method of de-inking printed paper stock.

Another object of the invention is to provide a particularly effective pre-treatment of pulp to facilitate and improve bleaching of the pulp.

These and other objects will be apparent from the following disclosure of our invention.

In regard to the pulp property changes produced by the present invention it will be understood that these are not always identical when the method is applied to different kinds of pulp having widely different properties in the untreated state, but the changes are generally characterized by decreased tensile strength, and increased wet stretch with substantially unchanged freeness. Other changes usually produced by the method are decreased bursting strength, increased tearing strength, increased dry stretch, increased porosity, increased softness, increased cleanliness, and improved optical properties including a more matte and optically level surface appearance of paper made from the treated pulp, and often increased brightness and opacity, all without any substantial decrease in freeness and often with a slight increase in freeness.

It should be noted that those changes cited as characteristic of the method of the present invention are in many respects directly opposite to the characteristic effects of conventional pulp refining methods, such as are carried out by the

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beater, Jordan, disk refiners, etc. Thus, when a pulp is subjected to the refining action of the beater the trend of property changes is towards increased tensile and bursting strength, decreased tearing strength, decreased freeness, decreased porosity, decreased brightness and decreased opacity. The property of stretch both wet and dry is, however, increased by beating as it is by the present method, although the degree of the change is not the same in each case, particularly in regard to wet stretch which by the present invention may be increased to a point well in excess of that possible by beating. Furthermore, as noted, the high-stretch pulp produced by beating will have its other principal properties altered in a direction diametrically opposed to that of the high-stretch pulp produced by the present invention.

It may be noted on the other hand that drying of pulp produces changes in its properties which in some respects resemble those caused by the method of the present invention. Thus drying usually causes a decrease in tensile strength and bursting strength, an increase in tearing strength, an increase in porosity and little change in freeness. Unlike the present invention, however, drying tends to cause a decrease in both wet and dry stretch properties. Also drying does not cause the improvement in cleanliness and the degree of change in optical properties which are characteristic of the present method. In addition, drying is a much more expensive process than the present method and requires a great deal more equipment and building space.

In the conventional pulp refining methods, as by the use of the beater, Jordan, disk refiners, etc., the typical quality effects are produced by causing some form of mutilation of the structure of the pulp fibres, such as abrasion of their surfaces, rupture of the surface membranes, bruising, fibrillation, splitting, cutting, etc., all in various degrees and combinations. To obtain such actions the fibres are subjected to relatively drastic forces in regard to such factors as speed, impact, pressure, and abrasion. In the case of the present method, however, the change produced in the individual fibres is something quite different. Here the effect produced is primarily a change in the shape or configuration of the fibres without any essential mutilation of their structure. Specifically, the requirement is to produce a greater degree of kinks, bends and twists of the individual fibres. The actions required to produce these changes are of a different

nature and involve a generally less drastic application of force than in the case of conventional refining. The method of the present invention provides a simple and inexpensive means of thus changing the configuration of wood pulp fibres to produce the modification of pulp properties as characterized in the foregoing description.

The following table illustrates one example of the characteristic quality effects produced by the present method in comparison with those produced by conventional pulp refining methods as exemplified by the beater, when both are applied to a given type of pulp, which in the case illustrated is undried, unbeaten, unbleached newsprint grade sulphite group.

TABLE

A comparison of the pulp property changes produced by conventional positive refining and by the method of the present invention

[Sample: Newsprint grade unbleached sulphite pulp.]

	Type of Treatment.....	Conventional Refining		Untreated Sample	Present Invention	
		Heavy Action	Medium Action		Medium Action	Heavy Action
1	Bursting Strength.....	132.9	109.0	84.6	66.0	58.6
2	Tearing Strength.....	80.8	89.1	130.2	147.4	161.8
3	Tensile Strength.....	11,590	10,620	8,040	5,270	4,870
4	Per Cent Stretch to Rupture.....	1.43	1.27	0.98	1.23	1.71
5	Bulk, cc. per gram.....	1.138	1.179	1.366	1.291	1.261
6	Air Porosity.....	339	229	24	18	10
7	Printing Opacity, Per Cent.....	73.9	78.9	86.1	88.2	85.3
8	Freeness.....	183	439	677	635	655
9	Wet Bursting Strength.....	1.334	1.156	0.786	0.802	0.774
10	Wet Tensile Strength.....	287	270	223	159	139
11	Per Cent Wet Stretch to Rupture.....	5.4	3.8	2.9	7.3	10.0
12	Couched Sheet Moisture Per Cent after Std. Wet Pressing.....	81.6	80.1	77.5	75.4	75.1

Referring to the table, the typical effects of conventional refining were obtained by processing the pulp in a laboratory beater operated in normal fashion. The property changes thus produced by the beater may be taken as representing, as to general trend relationships, the changes which are produced by the many other types of pulp refiners which are known commercially, and many others which have been proposed in the patent literature. No two of these refiners will produce exactly the same set of pulp properties and each one of them may be operated under varying conditions to produce a varying set of pulp properties, but all of them produce changes which in trend or direction may be clearly recognized as of similar general type to those produced by the beater. This kind of change in its broadest sense is embraced by the general term, the refining of pulp.

From the tabulated results it is seen that the method of the present invention has produced changes in pulp properties which are definitely and unmistakably different as to trend and type from those of conventional refining. In many cases the changes in individual properties are diametrically opposed to those of usual refining. Freeness is a rating of the drainage ability of pulp and is therefore an important indicator of its operating character on the wet end of the paper machine. Regular refining has caused a change of pulp properties in one direction, along with a progressive and marked reduction in freeness. The method of the present invention has caused a change of pulp properties generally in

the other direction, but with no essential change in freeness.

As noted, the characteristic changes in pulp properties which are produced by the present method are largely the result of the greater degree of kinks, bends and twists which the method imparts to the fibres. We have discovered also that this same kinking, bending and twisting action which the fibres undergo in the present invention is extremely effective in causing the separation or liberation of fibres which may be bonded together, and in doing this without the usual mutilations of fibre structure or the formation of fibre debris and the consequent lowering of freeness characteristic of other mechanical

methods of fibre liberation. The method is effective in this feature whether the bonds between the fibres are of the ligneous character as in wood or other vegetable fibrous structures, or as these may have been modified by various chemical pulping or softening agents, or whether the bonds are of the character as developed in a sheet of paper by drying with or without added bonding or sizing agents. Thus the method of the present invention is a new and effective means of substantially eliminating the small but undesirable shive content of regular commercial grades of pulp, such as sulphite, kraft, and soda pulps; and it also supplies an important new step in the production of so-called high-yield or semi-chemical pulps all of which must pass through an intermediate stage when a large percentage of shives or fibre bundles are present, the reduction of which to individual fibres to the extent required to form a clean sheet of paper, without undue expenditure of power or sacrifice of freeness, has presented a problem which heretofore has greatly curtailed the usefulness and application of high-yield pulps. The present method unbonds or liberates the individual fibres to an essentially complete degree and does this with a very low expenditure of power and without sacrifice of freeness. The same applies to the liberation of individual fibres by this method in re-pulping and de-inking of paper stock.

The method of the invention comprises forming the pulp in the presence of a limited amount of aqueous liquid into small, discrete nodules of fibres, and causing the nodulated pulp to form

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into rotatable units and travel rollwise under compression, thereby subjecting the nodules to mechanical pressure with continuous re-orientation of the nodules relative to the direction of applied pressure and thus imparting kinks, bends and twists to the pulp fibres or fibre bundles. It is evident that this action applies pressure repeatedly to different surfaces of the nodules and it is also evident that either the individual nodules or aggregates thereof may constitute the rotatable units, since in both essence and the effects produced, the method is satisfied whether the rotatable units of pulp are individual nodules, or roll-like or ball-like aggregates of nodules. It will be understood that when such aggregates of nodules rotate under pressure the individual nodules composing the aggregates must also move under pressure in circular fashion and thus receive pressure repeatedly to their different surfaces. In some instances, the nodules or aggregates thereof may rotate substantially separate from each other.

In a preferred method of carrying out the invention the rotatable units of pulp are caused to rotate under pressure on their different axes, this being obtained by some form of gyratory movement or by repeated cycles of essentially straight-line movement, preferably accompanied by regrouping of the nodules between the cycles of pressure rotation, or by a combination of gyratory and straight-line movements.

Stated in terms of mechanical means, the method of the invention consists of imparting kinks, bends, and twists to pulp fibres or fibre bundles by forming the pulp in the presence of an aqueous liquid into small discrete nodules or aggregates thereof and engaging the nodules or aggregates thereof between and in essentially non-slipping contact with opposed working elements which move relative to one another in a manner effective to cause the nodules or aggregates thereof to traverse rollwise between and under compression by the opposed working elements.

For a more complete understanding of the invention reference is had to the accompanying drawings wherein:

Fig. 1 is a diagrammatic representation of a nodule of fibres which may be of various sizes or shapes, no attempt having been made in this figure to suggest its precise shape.

Fig. 2 is a side view of a roll-like aggregate composed of a number of such discrete nodules in varying sizes and shapes.

Fig. 3 is a cross section on the line 3-3 of Fig. 2.

Fig. 4 is a diagrammatic illustration of a hand method of demonstrating the invention.

Fig. 5 is a view similar to Fig. 4 but showing an alternative hand method.

Fig. 6 is a partially sectioned perspective view of a machine for practicing the invention, and

Fig. 7 is a flow diagram of a pulp or paper mill system in which the machine of Fig. 6 is included.

For understanding the basic principles of the present method it is necessary first to consider the nature of a nodule of fibres, and then to consider the effects of rotating such a nodule under mechanical pressure. By the term "small discrete nodule of fibres" we mean a group of fibres existing as a more or less balled up entity, such as that into which a mass of pulp will separate when kneaded, rubbed, or tumbled at high consistency, for example, above 12%. Figure 1 is

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a diagrammatic representation of a nodule of fibres indicating the intertwining of the fibres about one another which occurs in nodules. The nodules 2 which make up a mass of nodulated pulp are not necessarily separated from each other, in fact they may be lightly adhering, but they are discrete in the sense that they exist as readily separable entities, and as noted, our invention may work on the separate nodules or on aggregates of them. The size of the nodules into which a given pulp will separate is in part a function of the length of the pulp fibres. It depends in part also on the kind and degree of the action employed in nodulating and on the consistency of the pulp. The nodules in the uncompressed state are seldom more than several fibre lengths in diameter, and they are often of somewhat non-uniform size as well as shape, depending on the kind and degree of action they have undergone in their formation or subsequent processing.

The roll-like or ball-like aggregates of nodules which may occur in the practice of the present invention are seldom over three-eighths of an inch in diameter as they are rotated under pressure and are often much smaller. Their size depends in part on the size of the individual nodules of which they are composed, and also on the degree of pressure which is employed, the length of the path in which they are rotated, and other variable factors. They tend to draw out, alter their shape and structure, and decrease in diameter under the action. We indicate the nature of the roll-like aggregates of nodules of fibres in Figure 2 which is a side view of such a roll composed of discrete nodules 2, and in Figure 3 which is a section through the roll shown in Figure 2. Figure 3 would also represent a section through a diameter of a ball-like aggregate of nodules of fibres. The fibres in the individual nodules are in a state of essentially random orientation and because of the size and shape of the nodule must also be in somewhat curved positions, even before the nodule is processed according to the present invention. It will be evident, therefore, that when such a nodule is caused to rotate under pressure, as for example with a gyratory movement when compressed between the thumb and finger, the intermingled fibres are subjected to kinking, bending and twisting forces exerted over very small radii of action and from constantly changing directions and that this will be so whether the nodules are rotated singly or in roll-like aggregate form. The structure of the intermingled fibres of the nodule has to continually shift and rearrange itself under pressure as the nodule rotates, and there must also result a considerable degree of bending and twisting of the individual fibres over and around each other, and since the diameter of the fibres is very small, this is an additional factor in producing short radius kinking of the fibres. It will be equally apparent that this small radius kinking, bending and twisting action could not be obtained by rotating under pressure a large wad of unnodulated fibre, for example, a wad of the well-felted and plane-oriented fibre structure such as results from the drainage of a pulp suspension on a wire. In other words, in order to effectively impart kinks to a short fibre as in wood pulp there must be the application of small radius forces and these are supplied in ideal fashion when a small nodule or aggregate thereof is rotated under pressure, but are lacking in the case of rotating a larger

unmodulated wad or a rolled-up felted sheet from a drainage wire. Of course, the pulp prior to the formation of nodules may in some cases be in a felted sheet form, if suitable mechanical action is provided whereby such a sheet is formed into nodules.

As has been noted the characteristic effects of the method of the present invention are obtained primarily by a kinking and twisting of the pulp fibres without essential mutilation of their structure. It will be apparent, however, that there is a limit to which pulp fibres may be subjected to such kinking, flexing and twisting action before appreciable mutilation of the fibre structure takes place. If this limit is exceeded, as may be accomplished by a sufficient extension of the time of action or by suitable increase of the action conditions of speed and applied pressure of the working elements, a still different set of pulp property changes may be produced over those described in the foregoing. In such cases of extreme action, much heavier for example than that characterized as Heavy Action in the table, fibre debris is produced and freeness may be substantially lowered but with opacity, brightness, and porosity still left at extremely high levels in comparison with the lowering of these properties accompanying a similar drop in freeness produced by ordinary refining methods as by the beater. Other important properties are also widely different from those of beaten pulp. While the more moderate range of action may serve for a majority of applications of our method, the extreme treatment may find use for certain products for which it is desirable to take advantage of the unique and special set of pulp properties which are now made available by such treatment. Thus it may be desirable in some cases to carry the action of our method beyond the point at which the freeness of the pulp is substantially unchanged, and obviously this may be done without in any way departing from the essence and scope of our method as described.

With respect to the marked effectiveness of the present invention in causing the liberation of fibres, it is evident that any shives or otherwise bonded fibres which are present in the rotating nodule or aggregate thereof will be subjected to the same small radius kinking, bending and twisting action as described, and that the resultant acute flexing of the bonded fibres from different directions will cause the bonds to yield and the fibres to be liberated. It is a particularly important feature of the method that fibres may thus be liberated without mutilation or breakdown of their individual structure. In cases where the method is being applied primarily for this de-shiving or fibre-liberation effect, the purely physical unbonding action as described may, if desired, be augmented by other means of promoting fibre liberation such as the use of high temperature, bond-softening chemicals, or both. Such use of chemical softening in combination with the physical action as described is particularly effective, in that the acute and continuous flexing of the fibres insures the most intimate incorporation of the softening agents into the bonds while they are under mechanical stress. Also, the high consistency at which the process may be carried out permits the economical use of a relatively high concentration of the chemical agent which is selected for the particular purpose in hand, whether this be the reduction of shives to single fibres, the

re-pulping, de-sizing or de-inking of paper stock, or the bleaching of pulp.

A particular advantage of the rotation feature of the present invention over other methods which might be employed to press the nodules on different surfaces, such as by heavy kneading of the nodules in mass form or by intermittent impact, is that the rotation permits a more positive local application of pressure together with a more positive and complete reorientation of the nodules to receive pressure repeatedly on changing surfaces and from different angles. There is also the very practical advantage of the rotation method in that it is very economical of power, since the rotating nodules or aggregates thereof serve in a sense as rollers between the working elements used to carry out the treatment.

In simple form the method of the invention may be carried out by hand. Thus, unbleached sulphite pulp in a heavy slush condition, for example at about 8% consistency, in a beaker is stirred with a glass rod to accentuate flocculation as an aid to subsequent formation of nodules. Then a handful of the pulp is squeezed free of loose water to about 20% consistency and the dewatered lump placed on a piece of rough canvas tacked to a table top, the canvas being used to supply the necessary condition of an essentially non-slipping contact with the pulp. Another piece of canvas is tacked to a small flat block, for example 6" x 6" x 1", which, held in the hand serves as one of the opposed working elements for carrying out the method, the canvas covered table top serving as the other. With a slow but firm downward movement and pressure and at the same time with a gyratory motion in a plane parallel to the table top, the canvas faced block is brought into engagement with the lump of pulp. Under this action the lump readily breaks down into small and rather uniform nodules and as the gyratory motion with downward pressure is continued, the nodules rotate under pressure between the opposed elements. A minute or two of this action, with pauses if necessary to re-group the nodules on the canvas, is sufficient to produce the results that have been described for the invention in the foregoing, namely, a practically complete elimination of any shives that may have been present in the original pulp, and a marked change in the properties of the pulp. The time that is required to produce a given degree of the effect will depend on the pressure that is used, the speed of the gyratory movement, and other factors. There are limits in this direction in hand operation, but with suitable mechanical equipment, the time required can be materially reduced, in some cases to a fraction of a second. This method of carrying out the invention is shown diagrammatically in Figure 4 in which 3 is a small block, sectioned in part to show the disposition of nodules beneath it, covered with rough canvas 4' and resting on nodules 2 which lie upon a second piece of rough canvas 4 tacked to a table top T. The method of the invention is performed when the block is pressed down firmly upon the nodules and given an oscillatory motion such that any point on the block, as the point 6, follows a closed path, as indicated by the curved arrow, in a plane parallel to the table top.

It will be noted that in the case illustrated, the formation of the nodules was effected by the same means that produced their rotation under

pressure, and the two steps were somewhat merged. If desired, the nodules could be formed separately and by different means, such as by a light crumbling or kneading of the dewatered lump of pulp. The nodules so formed could then be spread on the canvas to be then rotated under pressure by the use of the block as before. For the purpose of the present invention therefore it is not essential just how the nodules are formed or in what particular sequence, so long as they are formed in small size and are rotated under compression, according to the method of the present invention as described.

A simple hand treatment may be likewise used to carry out the process in another modification of the method. In such modification, the lump of dewatered pulp is placed on the canvas and engaged by the block held in the hand, in this case not with a gyratory movement but with a combined downward and forward movement with firm pressure. The lump of pulp is thereby broken down into a series of roll-like aggregates of nodules, which under further forward movement and pressure of the block are caused to rotate under its pressure. The rolling aggregates are disengaged either by raising the block or by continuing its forward movement until the aggregates have rolled from under its trailing edge. The rolled aggregates may then be re-grouped and the rolling and re-grouping actions repeated as many times as necessary to produce the desired degree of treatment. It is to be noted that in this action the pulp is engaged between the table and the block, designated as the opposed working elements, in a zone of their decreasing clearance which results from the approach of one working element as a whole towards the other, while at the same time the two working elements move tangentially relative to one another. As the action is repeated, it may be said that the two working elements move relatively to one another tangentially and with cyclical variation in mutual clearance between the opposed elements as a whole.

It is also possible to produce the required rotation of aggregates of nodules by a somewhat different type of relative action of the working elements. Thus, again using the canvas covered table top and a block with a tipped-up toe as shown in Figure 5, the lump of dewatered pulp is placed on the canvas as before, then the block, held firmly in a slightly angled position near the table so that it presents to the pulp a zone of decreasing clearance between the block and the table, is moved horizontally towards the pulp and thus engages it in the angle of diminishing clearance, and, as the block is moved ahead further, engages and compresses the pulp and causes it to form into a series of roll-like aggregates of nodules which rotate between the working elements and under pressure caused by the rolling progress of the aggregates through the zone of diminishing clearance. Here again, the rolled aggregates may be re-grouped and the action repeated as many times as necessary. This application of the method of our invention is illustrated in Figure 5 in which 7 is the canvas covered block with a tipped-up toe, here shown partly in section, which is moved towards the re-grouped nodules 8 and compresses them in the angle of diminishing clearance between the block 7, which is covered on its underside by canvas 4', and the canvas covering 4 on the table. Near some point such as 9, as the moving block engages and compresses the pulp 8, the non-slip-

ping contact between the pulp and the surfaces 4 and 4', together with the forward movement, effects formation of roll-like aggregates 10 of nodules which are then compressed and rolled by the further travel of the block. Analyzing the essential features of this action, it may be said of it that the pulp is engaged under pressure between and in essentially non-slipping contact with opposed working elements having a tangential movement relative to one another and mutually disposed to form a zone of decreasing clearance between one another in which one element is less inclined than the other to the direction of tangential movement and moves relatively to the zone of decreasing clearance in the direction of the decreasing clearance. In the present case, the table top is the working element which is less inclined to the direction of tangential movement and which although stationary in the absolute sense moves relatively to the zone of decreasing clearance formed by the block and the table and in the direction of the decreasing clearance.

It may be emphasized that the rolled aggregates as they are disengaged from between the working elements in this and the foregoing examples are still made up of small discrete nodules, adhering from the compression they have received during rotation. It requires only light application of force, as for example, crumbling between the fingers to break up the rolls into the individual nodules. In fact, this break up of the rolled aggregates, with the consequent re-orientation of the nodules, may take place when the aggregates are re-grouped between successive rotating actions in cycle as described. Obviously also, when a rolled aggregate is re-oriented and engaged at a changed angle from that of its previous direction of rotation, its internal nodulated structure will undergo breakdown and rearrangement under the action of the working elements as the new cycle of rotation gets under way.

The method of the present invention may be carried out over a wide range of starting pulp consistency from a lower value of about 2% consistency to a merely moist condition as at about 60% consistency. It is obvious however that when the nodules or aggregates thereof are rotated under pressure, the local consistency in that stage is bound to be fairly high regardless of the starting consistency. If the starting consistency is low there will be local dewatering of the rotating bodies or units of pulp, even though the expressed water may be immediately re-absorbed by the units when they are disengaged from the zone of action. A practical limitation on the low consistency side is that the opposed working elements must engage sufficient pulp to form rotating units, a condition which would be difficult to provide with a thin suspension of pulp fibres. It might, however, be provided with a consistency of as low as 2% or 3%, although it is preferred to carry out the process at higher consistencies. If desired, in using the method on low consistency stock, one or both of the opposed working elements may be provided with suitable drainage characteristics to permit removal of water which is pressed out by the action of the working elements in carrying out the method as described. We have found that the accentuated flocculation, such as is obtained by agitating and shearing the pulp in a heavy slush condition, for example at a consistency from 6 to 12%, is a particularly effective means of insuring easy formation of small discrete nodules after further dewatering, as is accomplished either simultane-

ously with rotating the pulp under pressure as has been described, or as a separate nodulation step carried out prior to the rotation treatment.

For purposes of the present invention it is clear that the active surfaces of the opposed working elements between which the pulp is rotated must be of a sufficiently rough texture or character to engage the pulp in essentially non-slipping contact. Thus the surfaces may be knurled or otherwise figured, or they may be faced with a material having a suitably rough surface.

It is also clear from the examples cited that the opposed working elements when causing the rotation under pressure of the units of pulp must possess relative tangential velocity. In view of the possible variety of shapes and positions of the working elements with which the method may be carried out, such relative tangential velocity of the opposed elements is most easily defined with reference to the location where the clearance between the elements is a minimum. We may define the relative tangential velocity as the velocity of one point of one surface with reference to the nearest point on the opposing surface in planes perpendicularly to a straight line drawn between the two points. One element may be moving and the other stationary, or both elements may be moving in the same or opposite directions, so long as they move with relative tangential velocity so as to insure that the units of pulp rotate. In general, the relative tangential velocity of the working elements employed in carrying out the present invention is of a relatively low order of magnitude, as compared with the relative velocity of the working elements used in conventional pulp refining methods such as those carried out by the beater, Jordan, disk refiners, etc. With the types of apparatus which are cited herein for exemplifying the method, we would usually operate at relative tangential velocities in the range of 50 to 300 ft. per min. The main factor limiting the velocity on the high side is the requirement that the rotating bodies or units of pulp must not slip or smear on the surfaces of the working elements since this would prevent the necessary rotation. Obviously with suitable adjustment or design of apparatus it might be possible to provide this requirement at higher velocities than those above indicated without in any way departing from the essential features of the present invention as claimed.

The minimum clearance which is provided between the working elements which engage and rotate the pulp will depend on the size of the nodules or aggregates thereof under treatment which in turn may depend on several conditions of any particular application of the process, such as the nature of the fibrous stock, the kind and degree of its nodulation, and on the pressure and time of rotation. For normal applications of the process thus far studied, the minimum clearance between the working elements is in the range of one sixty-fourth to three-eighths of an inch.

By the term "rollwise traverse" as used in the present disclosure in describing the motion of the nodules or aggregates thereof under the action of the opposed working elements, we do not intend to imply that the pulp bodies must necessarily make a complete revolution, although they may do so not only once, but a number of times. This term also includes the condition in which the pulp bodies move in gyratory or oscillatory fashion while in non-slipping engagement with, and under pressure between, the opposed working elements. This would be the case, for exam-

ple, when the pulp bodies are gripped under pressure between opposed working elements which move relatively to one another in parallel planes with a gyratory motion of small amplitude. The pulp bodies will then travel in small circular paths in contact with each element and may thus be said to rotate although they may never make a complete revolution. The same would apply to the case of roll-like aggregates of nodules gripped under pressure between the opposed working elements moving relatively forward and backward in parallel planes in short stroke so that the roll-like aggregates will traverse forward and back rollerwise between the elements but without making a complete revolution. Here again, for the purposes of the present invention, the aggregates would be considered as rotating. In all cases there must be some degree of traverse of the centers of gravity of the rotating bodies with respect to each of the opposed working elements which grips them.

It is obvious that the method of the present invention may be carried out in a wide variety of apparatus. Once the principle of the treatment is recognized, it is easy to see how certain existing apparatus, with the necessary modifications of operating conditions, might be used, and to design new apparatus for the purpose. A suitable apparatus for carrying out the method and one adaptable to a wide range of consistency might comprise two coacting metal plates with roughened surfaces suitably mounted one above the other in horizontal position. The two flat opposed surfaces of the plates would be knurled. The top plate would be provided with a suitable mechanism having a compound cyclical movement by which it approaches and recedes from the lower plate while at the same time passing forward and back along an axis of the lower plate with a stroke of about ten inches and a frequency of about thirty cycles per minute, the two movements so synchronized that the downward movement takes place near the start of the forward movement and the upward lift of the plate takes place at the start of its backward travel. The lower plate is provided with a suitable mechanism having a gyratory movement in a horizontal plane, the amplitude of which is about one inch and the frequency about five hundred cycles per minute. Suitable slides and stops are provided so that the top plate in its downward movement approaches the bottom plate to a small clearance without contact, a suitable minimum clearance being about one-sixteenth of an inch, and in its upward movement recedes from the lower plate an inch or two or as is sufficient to clear the pulp on the bottom plate. In intermittent cycle, pulp in loose form is fed onto the lower plate with even spreading to a depth of about one-quarter of an inch and in the zone exposed by the receding or trailing edge of the top plate as it moves forward. On its return backward pass in its raised position, the top plate comes to a position above the pulp spread on part of the bottom plate, and on its next forward and downward movement engages and compresses the pulp, and assisted by the gyratory movement of the opposed bottom plate, forms the pulp into small nodules and rotates them progressively forward under pressure in curved paths of trochoidal form. As the cycle repeats itself the rolled nodules are eventually discharged from the zone of action at the edge of the plate opposite to which the pulp was fed and engaged by the plates. The downward pressure which the top plate ex-

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erts on the pulp may be controlled at the desired amount by the weight supplied by the plate itself or by downward acting springs, or other mechanism. Suitable operating pressure in many applications of the process are in the range of one to twenty pounds per square inch, expressed in terms of mutual compressive force in pounds per square inch of the surface of one of the elements which is engaged with the pulp. In some applications of the process still higher pressures may be used to advantage.

With such an apparatus in which one at least of the working elements is provided with a gyratory motion, the pulp supplied may be in a variety of physical conditions. It may consist of loose nodules previously formed, or it may consist of felted sheets or mats of pulp having suitable thickness, for example $\frac{1}{4}$ ", or it may consist of loose slush pulp. In the case of loose slush pulp and mats, the formation of nodules or rotatable units of pulp takes place immediately upon engagement of the pulp between the working elements.

The same apparatus but with slightly modified action may be used to carry out the process in its form in which roll-like aggregates of nodules are formed and rotated under pressure. The only change necessary for this purpose is that the bottom plate, instead of having a gyratory movement, may be stationary. For this purpose also, the depth of the layer of pulp which is spread on the bottom plate in its feed zone may more conveniently be about one inch instead of one-quarter inch. The pulp is formed into roll-like aggregates of nodules which progress roller-wise under the repeated motions of the top plate. In some cases it may be desirable to increase the effectiveness of the action by causing a re-orientation of the roll-like aggregates between successive actions on them by the top plate. This is done while the aggregates are out of engagement with the top plate during its backward pass in the raised position. It may be accomplished by simple mechanical means or by the application of compressed air through suitably placed jets.

Another suitable apparatus for carrying out the method of the present invention might comprise a cylindrical trough, preferably with a rough lining, having a number of relatively broad shoes with tipped up toes travelling in circular paths in it at small adjustable clearance from its surface. The feed would be such that the trough carried only a shallow layer of pulp, and the shoes would rub, roll and press the pulp caught underneath them, so that when it reached the end of the trough it would be in the form of crumbs to different surfaces of which pressure had been repeatedly applied by the rolling action of the shoes. The shoes could suitably be mounted on spirally arranged arms extending from a rotatable shaft mounted along the longitudinal axis of the trough, and behind each shoe could run a scraper mounted at an angle for the purpose of moving pulp treated by that shoe into the path of the next shoe along the shaft.

Figure 6 is a partly sectioned view of the suitable apparatus described in the foregoing paragraph in which 11 is a cylindrical metal shell with a roughened interior surface such as would be obtained by knurling the surface. A shaft 12, which is axially disposed within the cylinder 11, supported on exterior bearings and connected to a driving means whereby the shaft may be rotated in a clockwise direction as viewed from the sectioned end, supports a series of shoes 13 which

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are connected to the shaft by the supporting radial arms 14 and the hubs 15, the latter being keyed to the shaft 12. Scrapers 16 serve to mix and re-orient the treated pulp and effect its passage through the apparatus. Pulp to be treated is fed into the inlet hopper 17, then passes along the shell 11 to the outlet 18. During its passage along the shell the pulp forms a layer 19 on the bottom of the shell through and over which the rotating shoes pass. Part of this layer 19 is pushed ahead of the shoes in their course toward the top of the shell, and during this passage the picked-up pulp feeds back into the zone of decreasing clearance between the shoes and the shell into active engagement by which it is compressed and formed into roll-like aggregates of nodules 10 which are rotated under compression between the shoe and the shell surfaces, finally being freed by the further travel of the shoes and dropping back into the pulp layer 19 for further action by the same or adjacent shoes. At 20 we indicate an excess of picked-up pulp which did not pass back through the zone of decreasing clearance and which will drop back into the pulp mass 19 on further rotation of the shoe.

When such an apparatus as described in the foregoing paragraphs is operated, the shallow layer of pulp is engaged between the essentially non-slipping surfaces of the shoes and the trough and is formed into roll-like aggregates of discrete nodules. These aggregates of nodules assume a diameter adapted to the clearance between the working elements and start to rotate, substantially separated from each other, between the working elements and traverse in the direction of the moving shoe element at approximately half the speed of the shoe. These aggregates of nodules in their rolling progress toward the trailing end of the shoe element are compressed in diameter by the diminishing clearance between the working elements provided by the tipped up toe of the shoe.

It will be apparent from the foregoing description of the invention that the treated pulp, as it emerges from the zone of action of the working elements which cause it to rotate under pressure, will still be in the form of nodules regardless of whether these have been rotated singly or in aggregate form. The fibres of the treated nodules will be more or less firmly interlocked in their accentuated kinked and twisted condition as a result of the action they have undergone. For usual papermaking processes it is of course necessary to reduce the nodules again to the form of a thin aqueous suspension of well dispersed fibres. This is accomplished by suitable agitation with the necessary amount of added water. This step may be termed re-slushing of the nodules. In cases where the method has been carried out in the lower consistency range, for example, below 15%, the interlocking of the fibres in the nodules is less tight than in the case of higher consistency operation, for example, 20% and higher. We have found that re-slushing of the nodules, particularly when the fibres are tightly interlocked, is greatly facilitated by adding at first only a limited amount of water to bring the pulp to a heavy slush condition, and then agitating by a slow shearing action in this state to loosen the interlocked fibrous structure of the nodules, after which the balance of the water may be added and more active agitation supplied to the thin stock. For example, nodules issuing from the process at 25% consistency are first given water to about 8% to 10% consistency, and

then subjected to slow agitation by passing through the same type of trough-paddle apparatus as described in the following paragraph for carrying out the pre-nodulation step at about the same consistency. A regular cut-flight screw conveyor would serve a similar purpose. After this preliminary treatment the heavy slush stock may be given the balance of the required water, for example enough to bring the stock to 2% consistency, and the re-slushing or dispersion of the fibres completed by any convenient means of rather violent agitation of the thin suspension. In many cases mere passage of the stock through the centrifugal pumps of normal subsequent operations is sufficient for this purpose.

In practicing the method of the present invention where separate steps of dewatering and nodulation of the pulp are to be used, as for example in carrying out the method at higher pulp consistencies in the range 15% to 60%, the pulp is first brought by any convenient means to a consistency of about 6% to 10% and then it is given an extreme degree of flocculation. A suitable apparatus for performing this step might comprise a horizontal trough in which is mounted a rotatable longitudinal shaft to which a series of simple blades are attached at right angles, the blades being slightly angled from a plane perpendicular to the axis of the shaft, so that when pulp is fed at one end of the trough it will be subjected to successive shearing actions by the rotating blades and at the same time progressively advanced through the trough. The speed of the shaft might be about 60 revolutions per minute and the blade tips may be about ten inches long from the shaft centres. The stock discharged from the trough will be in a state of extreme flocculation, a condition which might be termed pre-nodulation. The next dewatering step to bring the pre-nodulated stock to higher consistency might be carried out in a regular screw press or in a suitable horn-angle press. The cake-like mass of pulp from the dewatering apparatus can now be reduced to nodules with great ease, and a convenient means is to subject the cake to the action of rotating finger bars, or to pass the pulp through a short length of regular cut-flight screw conveyor. The nodulated pulp is now in a particularly favorable state for introduction between the opposed working elements of the apparatus for carrying out the main step of the present invention as has been described in the foregoing. Or as noted, the opposed working elements themselves may be relied upon to cause the breakdown of the pre-nodulated dewatered cake into nodules.

There are various arrangements of equipment suitable for the large scale application of the method of our invention. One example of such an arrangement is indicated in the diagram of Figure 7 in which 21 represents a rotary or other dewatering device to which is supplied stock at low consistency, say below 1% as it might come from a screening system. Thickened stock coming from unit 21 at 6% to 10% consistency then passes to the pre-nodulating unit 22 which may be constructed as described in the foregoing paragraph. After pre-nodulation the stock passes into a second dewatering unit 23 which may conveniently be a screw press. The screw press dewaterers the pre-nodulated stock to 15% or higher consistency and this stock then passes to an apparatus 11 such as is shown in Figure 6. Controlled amounts of white water from the unit 23 may be added with the stock to unit 11 through

the valve 24 to regulate the consistency of the stock under treatment in unit 11. Stock from unit 11 then passes to unit 25, together with the balance of the screw press white water, and there the stock and white water are thoroughly mixed and agitated at 6% to 10% consistency to promote loosening of the structure of the nodules of fibres. From the unit 25 the stock may pass to the suction inlet of a centrifugal pump 26 together with further dilution water. This dilution water may be part of the white water from the unit 21 which passes to the pump inlet through the valve 27, the balance being discarded through valve 28. The pump 26 promotes dispersion of the processed nodules into single fibres and serves to pass on the treated stock for use or storage.

We use the term "wood pulp" in the present disclosure and claims to denote any of the general types of fibrous material used in the manufacture of paper and board. We further intend to include in this definition any particular state or condition in which the material may be or may have previously been, that is, whether it is washed or unwashed, screened or unscreened, bleached or unbleached, beaten or unbeaten, undried or previously dried as pulp or as paper products. It is understood that most of such materials contain a fraction of so-called shives or undissociated fibre bundles, and of course an unscreened pulp contains a somewhat larger fraction of such shives, and a partially disintegrated high-yield or semi-chemical pulp contains a still larger fraction, and our definition of the term wood pulp is not intended to exclude the presence of such fractions of not fully reduced material. In fact, as noted, the present method serves particularly well to reduce or eliminate this generally undesirable shive fraction of pulp. In practice it has even been found that our method is effective to reduce chemically softened sawdust to a state of complete fibre liberation suitable to permit its use in relatively high grade paper.

In applying the process to so-called high-yield pulps, it is first necessary to reduce the lignocellulose material to an essentially fibrous condition. This may be accomplished by any suitable means, such as are well known in the art. For example, wood chips may be softened by a mild digestion under pressure with any of the well known chemical pulping agents, and the softened chips disintegrated to a fibrous condition by subjecting them to heavy crushing and rubbing action or by passing them through a suitable disk refiner or jordan, or it may be accomplished by subjecting them to a treating action of a type essentially similar to that used in carrying out the present invention. Obviously in applying the action to such disintegration, the nature and operating conditions of the working elements would require suitable modification. The product, although of a fibrous nature would still contain a large amount of shives or bundles of undissociated fibres. The pulp in this state may then be treated by the method of the present invention to complete effectively the liberation of single fibres. For this application of the process, the gyratory type of action in rotating separate nodules with the application of fairly heavy pressure is particularly effective.

In applying the process to the re-pulping or de-inking of paper stock it is again first necessary to reduce the paper or paper board to sufficiently fibrous condition to permit nodulation. This may be accomplished by subjecting the paper stock

to a limited shredding, rubbing and kneading action in the presence of an aqueous medium with or without the addition of special chemical agents. Here again, the partial disintegration may be effectively accomplished by the same general type of action as used in carrying out the present invention, and in some cases the whole re-pulping treatment may be carried out in a unit apparatus of this nature. There are also other existing types of re-pulping apparatus which could serve for the preliminary disintegration step, but for the present purpose the action is carried only to the point where the stock is sufficiently disintegrated so that it can be formed into small nodules which may be rotated under pressure either singly or in roll-like or ball-like aggregate form according to the method of the present invention. The nodules as first formed will contain a considerable amount of bits of undissociated paper stock but these are fully and effectively reduced to liberated fibres by the rotation of the nodules under pressure. In the case where de-inking is an object, the general procedure is the same. Any suitable de-inking agent may be incorporated with the stock either during the preliminary disintegration or at the rotation stage, with or without use of increased temperature. The very positive contortions and mutual interaction which the fibres of the rotating nodules undergo is a particularly effective aid to the chemical agent in causing the ink particles to separate from the fibres so that they may be readily removed in subsequent re-slushing and washing operations.

We have discovered that the method of the present invention provides a very effective step for improving pulp bleaching processes. It is well known that the shives or fibre bundles which occur in wood pulp are the principal source of many of the difficulties in obtaining uniform economical bleaching in a short period of time. This is because the shives are much more resistant than the single fibres to the action of the bleaching chemicals and therefore in a sense control the reaction in regard to such economic factors as the required amount and concentration of chemicals and the required time of bleaching. It also happens that the requirements of chemicals and time to effect full bleaching of the shives are often not the most suitable for the single fibres which make up the bulk of the pulp, and as a result of this there is a general tendency to over-bleach the pulp in order to fully bleach the few shives, since if the latter are not fully bleached they remain as conspicuous blemishes in the pulp and converted products made therefrom. By using the method of the present invention, however, either as a preliminary step or directly combined with the bleaching operation, the almost complete elimination of shives effected by the method permits the use of less bleaching chemicals, a shorter bleaching time, and at the same time yields a product of more uniform and controlled quality than has been possible by processes hitherto employed. Where the present method is used as a preliminary step to the bleaching operation, the processed nodules of pulp are fed to the regular bleaching equipment and process, with or without re-slushing of the nodules, depending on the requirements of the particular type of bleaching which is being used. Where it is desired to combine the present method directly with the bleaching operation, part or all of the bleaching chemicals may be added to the pulp before or during its treatment by the method of the present invention.

The characteristic physical actions of the method serve as a particularly effective means of assuring the most intimate mixing of the bleaching chemical with the pulp and of incorporating it into the actual structure of the individual fibres while they are continually under mechanical stress, with the result that the subsequent bleaching reactions proceed much more uniformly and rapidly than in bleaching operations hitherto employed. In addition, the combined physical and chemical actions, plus the elimination of the resistant shives, permits the use of less than the usual amount of chemical agent to yield an improved bleached product. After the nodulated pulp has thus been rotated under compression in the presence of the bleaching agent, the nodules with the contained agent may be conveyed to a holding vessel, either as a batch or as a continuous treatment, to give a dwell time sufficient to complete the bleaching reaction to the desired point. To those familiar with the art, obvious variations of procedure will suggest themselves for adapting the general method as disclosed to the particular requirements of the different types of single and multi-stage bleaching operations.

By the term "wet stretch" as used in the foregoing disclosure we mean the increase in length, expressed as a percentage of the original length, which a strip of wet pulp sheet will endure before rupture ensues. We determine the wet stretch of pulps by forming and wet pressing handsheets in a standardized fashion to give pulp sheets which contain 65% to 85% water, the exact water content being different for and characteristic of various pulps. We then clamp the wet pulp sheets over a flat rubber diaphragm by means of a flat annular ring having an internal diameter less than those of the diaphragm and pulp sheet and distend the diaphragm and pulp sheet by hydraulic pressure admitted under the diaphragm until the sheet ruptures. We measure the volume of fluid required to distend the initially flat, circular test area into the form substantially that of a sector of a sphere obtaining at the moment of sheet rupture, and calculate from this volume the length of a great-circle arc across the spherical surface. The length of this arc is then the length at rupture of any straight, narrow, strip of the pulp sheet which had an initial unstressed length equal to the inside diameter of the clamping ring. The difference between this length of the arm at rupture and the length of the corresponding unstressed strip, divided by the latter length and expressed as a percentage, is what we call the wet stretch of the pulp.

While ordinarily the present method would be applied to pulp in mixture with water alone, we do not intend to exclude the possibility that other substances or chemicals might be present also. Thus, when the method is applied to unwashed chemical pulp, there would be present the spent chemicals of the pulping liquor, or, in some applications of the method there might even be the addition of certain chemicals or reagents to produce special effects, as might be the case when applying the method to pulp being reclaimed from waste paper stock or from printed paper stock, when de-sizing or de-inking chemical reagents might be added to the stock before or during the treatment. In some cases also we have found that higher temperature is an aid in carrying out this process, and this may be obtained by steaming the stock before or during the treatment, or

by other convenient heating means. Similarly, a chemical or semi-chemical pulp may be treated by the present method while it is still hot from the chemical pulping process or even in the presence of the hot pulping liquor. Obviously, chemicals may be added to the pulp either prior to or during the treatment by our method. In cases where washing is an object, water may be added to and removed from the pulp while under treatment by providing the working elements with suitable drainage characteristics.

We have found that the characteristic pulp property changes which are effected by the present method may be accentuated by allowing the rolled nodules of pulp to remain in that form for some time, for example, several hours or more, before re-slushing, and this is particularly true when the method is applied to pulp at consistencies above 20%. Such accentuation of the property changes is also caused by holding the rolled nodules under pressure before re-slushing, as might be conveniently done by storage of the rolled nodules in pressed bale form. An extreme degree of the effect is obtained by partial or complete drying of the pulp in the rolled nodule form which may conveniently be done in a rotating drum dryer with the application of hot air, or may be accomplished by transporting the rolled nodules on a continuous wire mesh belt through a suitable drying chamber.

While, as stated, the pulp property changes produced by the present method always follow characteristic trends as described, it is apparent that the relationships between the changes of the individual properties will depend somewhat on the various conditions which are employed in carrying out the process in any particular case. Thus there is a large degree of control over the effect produced by selection of conditions, just as there is in the case of conventional pulp refining to produce the property changes which in many respects are the direct opposite of those of the present method. Among the factors which are available for control of the effect to be produced by the present method are the consistency of pulp, the relative tangential velocity of the opposed surfaces, the minimum clearance which is provided between the opposed surfaces, and the pressure applied by them to the pulp, the temperature of the pulp, and the duration of the treatment, as well as subsequent treatments of the rolled units of pulp as described. Just as in the case of conventional refining, the particular set of conditions which are employed will depend on the particular requirements of the use to which the pulp is to be put. In fact, one of the values of the present method is that it provides a simple and inexpensive means of greatly widening the range of properties which may be obtained from a given pulp, thus broadening the range of its usefulness and value. In many ways, therefore, our method presents a new and valuable addition to the known paper making art.

The economical features of the present method are several. In the first place, relatively simple and small size equipment is required. In the second place, the power requirements of the method are unusually low as compared with most pulp treating methods, partly because the rolling nodules or aggregates thereof serve as rollers between the moving surfaces. In the third place, the high consistency of the rolling aggregates plus the relatively low speed of all the movements results in a low power loss through liquid shear as compared with the case of many

pulp treating methods which operate at low consistencies and high speed. Then, also, there are the direct and indirect economies resulting from the pulp property modifications which are made possible by the present method. Thus, a user desiring some of the softer characteristics of a predried pulp can now obtain them by our simple mechanical method instead of by the much more expensive method of drying the pulp. In the same manner, a user desiring a high stretch pulp can obtain it by our method and still maintain a high freeness property whereas, if he resorted to a beating treatment, not only would the beating treatment be more expensive, but also it would produce a large drop in freeness which would result in lower paper machine efficiency. In general, for such uses as require the properties of softness, high stretch, porosity, cleanliness, and even matte texture, the application of the present method permits the use of a lower cost pulp or furnish than would otherwise be possible, and the high freeness which may be maintained by the method is generally an economic advantage in all conversion operations. Since the use of the method permits a ready means of greatly widening the range of properties which are obtainable from a given pulp supply, it is apparent that its use will simplify the pulp supply problem of a converter making a variety of types and grades of paper products. In similar manner its use by a primary pulp producer will permit him to offer a variety of pulp qualities for particular uses without the necessity of added expense and operating complications of a variety of pulping processes or their modifications. There are obvious economic advantages in the case of the high-yield, high-freeness, shive-free pulps which are made possible by the use of the method of the present invention. These include the savings in wood and chemical costs; the more economical operation of converting machines due to the high freeness of the pulp; and the use of the shive-free high-yield pulp in higher grades of paper products than has hitherto been possible because of the shives and relatively poor appearance.

What we therefore claim and desire to secure by Letters Patent is:

1. The method of processing papermaking pulp which comprises dewatering an aqueous suspension of pulp fibres to high consistency, working the pulp into the form of small, moist, discrete, crumb-like nodules in which the fibres are randomly intertwined, compressing the nodules between opposed working surfaces which are roughened to provide traction for the nodules without obstructing rolling traverse of the nodules on the surfaces, and rolling the nodules transversely on the surfaces while changing continually the direction in which the nodules traverse the surfaces and while keeping the nodules under compression, thereby to reorient the nodules continually with reference to the direction of compression.

2. The method of processing papermaking pulp which comprises dewatering an aqueous suspension of pulp fibres and working the pulp into small, moist, discrete crumb-like nodules in which the fibres are randomly intertwined, and rolling the nodules tractively in traverse of two opposed working surfaces and in changing directions relative to said surfaces while the nodules are under compression by said surfaces, and then adding water to the nodules to rework the pulp into an aqueous suspension of pulp fibres.

3. The method of processing papermaking pulp which comprises dewatering an aqueous suspension of pulp fibres to a pulp of high consistency, working the pulp into small, moist, discrete, crumb-like nodules in which the fibres are randomly intertwined, compressing the nodules between opposed working surfaces which are roughened to provide traction for the nodules without obstructing rolling traverse of the nodules on the surfaces, and imparting a translatory gyratory motion to one of the surfaces about an axis extending in the direction of compression to roll the nodules in continually changing directions in traverse of and under compression by said surfaces, thereby to reorient the nodules continually with reference to the direction of applied pressure and increase the degree of contortion of the fibres.

4. The method of processing papermaking pulp which comprises dewatering an aqueous suspension of pulp fibres to a pulp of high consistency, working the pulp into small, moist, discrete, crumb-like nodules in which the fibres are randomly intertwined, compressing the nodules between opposed working surfaces which are roughened to provide traction for the nodules without obstructing rolling traverse of the nodules on the surfaces, and moving one of the surfaces relative to the other at a velocity of between fifty and three hundred feet per minute about an axis extending in the direction of compression to roll the nodules in traverse of and under compression by said surfaces, thereby to reorient the nodules repeatedly with reference to the direction of applied pressure and increase the degree of contortion of the fibres.

5. The method of processing papermaking pulp which comprises dewatering an aqueous suspension of pulp fibres to high consistency while agitating the suspension to work the pulp into the form of small, moist, discrete, crumb-like nodules in which the fibres are randomly intertwined, compressing said nodules in a relatively thin layer between opposed working surfaces, causing the nodules while under compression to be reoriented repeatedly with reference to the direction of compression, and then adding water to the nodules to rework the pulp into an aqueous suspension of pulp fibres.

6. The method of processing papermaking pulp which comprises dewatering and working an aqueous suspension of pulp fibres into small, moist, discrete, crumb-like nodules in which the fibres are randomly intertwined, compressing the nodules between opposed working surfaces, rolling the nodules in traverse of and under compression by said surfaces, releasing the nodules from compression but keeping them in nodular form, compressing the nodules again between opposed working surfaces after reorienting them with reference to the surfaces, and rerolling the nodules in traverse of and under compression by the surfaces.

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