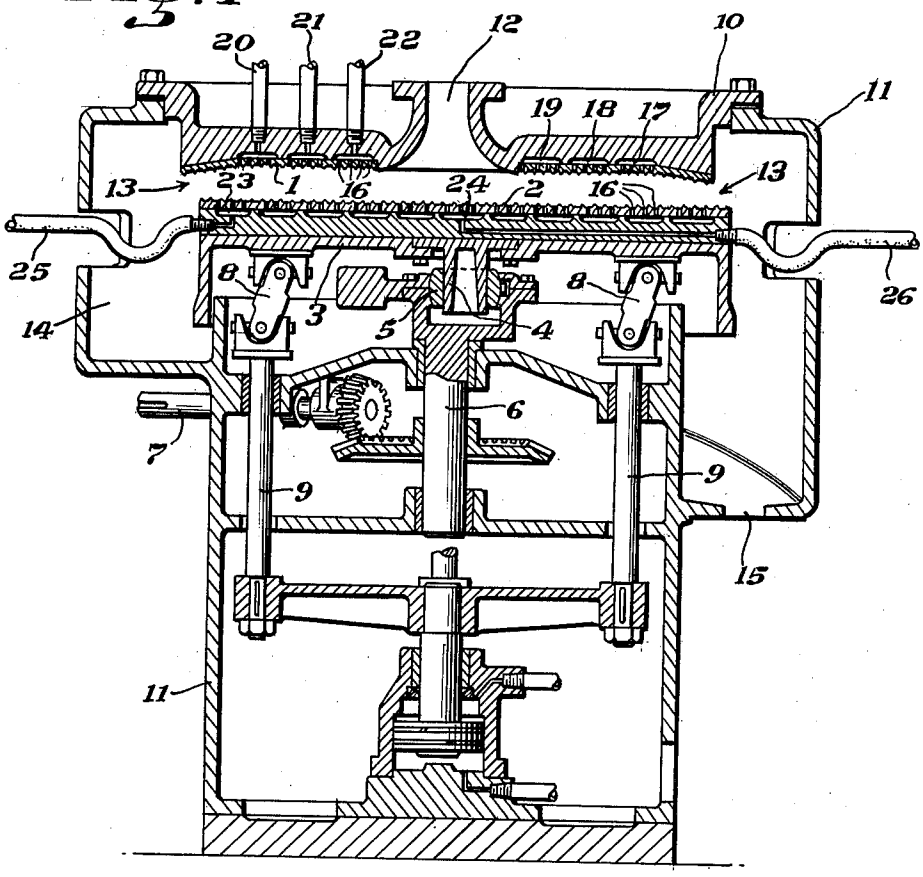
June 9, 1953 H. S. HILL ET AL 2,641,164

METHOD FOR PROCESSING FIBROUS PULP

Filed July 8, 1946

Fig. 1



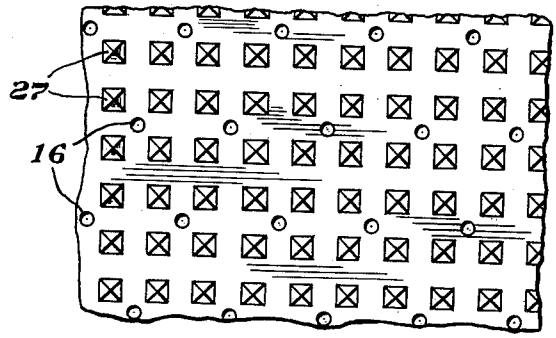
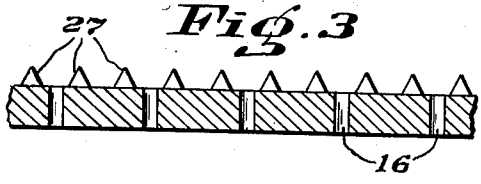


Fig. 2

Fig. 3



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METHOD FOR PROCESSING FIBROUS PULP

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Application July 8, 1946, Serial No. 681,918

18 Claims. (Cl. 92—20)

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The present invention relates to a method for processing fibrous material to permit the separation and selection of constituent materials with respect to fibre or particle size, with particular reference to papermaking pulp.

A principal object of our invention is to provide a method for effecting the separation of selected size classes of fibres and particles which may be present in a fibrous pulp.

Another object of our invention is to provide a unit process for the liberation of fibres from fibrous materials and the screening classification of the resulting pulp directly as it is formed.

A further object is to provide an improved method for the de-inking of waste printed paper.

Other objects will be apparent from the following description and the appended claims.

Most of the existing methods of screening and fractionating a fibrous pulp into two or more fractions are carried out at very low pulp consistencies, usually below 1%, the main reason for this being that only in this way has it hitherto been possible to provide the necessary degree of agitation of the pulp to permit the separation to take place. One of the fundamental consequences of this very great preponderance of process water in relation to fibre is that the direct, primary actions of the process are necessarily directed to the water, depending on indirect secondary results of this to produce the desired manipulation of the fibres. It is one of the fundamental characteristics of the method of our invention that the fibres themselves receive the direct and positive manipulation and that the water serves in a specialized role as a transport agent. In this way, we have obtained a degree of control and efficiency of fibre separation hitherto unrealized.

In brief, our method consists of forming and compressing a relatively thin layer of pulp between and in tractive contact with two opposed working surfaces at least one of which is perforated so as to permit drainage of liquid therethrough, gyrationally agitating the layer of pulp by imparting to the working surfaces relative tangential motion of a gyratory character while maintaining their compression of and their tractive contact with the layer of pulp, providing the presence of an excess of a liquid in the layer of pulp while it is thus being agitated, causing excess liquid to flow from the agitated pulp through the perforated surface in contact therewith whereby the flow of liquid carries with it relatively finer constituents of the pulp, and continuing the agitation of the layer of pulp and the flow of liquid therefrom until the desired fraction

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of finer constituents has been removed from the pulp.

For clearer understanding of our invention and how it is carried out, the above listed essential features are defined and explained in detail as follows, taking them up in the order listed.

A "relatively thin layer of pulp" refers to the condition of a quantity of pulp as compressed between two substantially parallel surfaces of relatively large area in relation to the thickness of the layer, the latter dimension being usually in the range of three-eighths to one-sixty fourth of an inch. We may "form" the layer in various convenient ways, as, for example, by spreading a layer of pulp on one surface and bringing the opposed surface into contact, or by feeding a flow of pulp into and through a relatively thin working space between two opposed surfaces already in substantially parallel, working positions, and thereby, in both cases, "forming" a layer of pulp between the surfaces. Water is usually present in the initial pulp, and obviously a layer of pulp under compression will be of relatively high consistency in comparison with that employed in ordinary screening operations, and obviously also, the consistency of the layer of pulp under compression will depend on the degree of compression. In the usual practice of our invention, consistencies of the pulp layer range from 4 to 50%. Regardless of the condition of the pulp at the start, it is always very strongly nodulated almost instantaneously after it has been exposed to the gyrational agitation as described herein. The nodules may be closely packed in the layer, or loosely packed, or in some cases even somewhat discontinuous in the layer. The compression may be light or heavy depending on the effect desired from a particular application of the process.

The specified condition of "tractive contact" between the layer of pulp and the working surfaces is that in virtue of which there is a strong resistance to slipping of the pulp on the working surfaces, in the same sense that there is intended to be tractive contact and no slipping between the tread of an automobile tire and the surface of the highway. A main requirement in both cases is that there shall be a rollwise type of traverse over the surface, as opposed to a slipping type of traverse. In the case of the pulp, the traverse is by nodules of the pulp or rotatable units thereof. In order to provide and maintain the tractive contact between the pulp and the working surfaces, the latter must have a suitably rough or figured surface texture to promote such traction, and a level enough contour to permit

the traverse, without undue obstruction or binding, of the traversing units of pulp. It will be apparent that both the relative tangential velocity of the surfaces and the pressure which they exert on the pulp are also limiting factors in maintaining their traction with the pulp, in the same way that corresponding factors exist in the case of the automobile tire where excessive speed on a curved course would cause a skid, and too high a pressure would deform the tire or wheel so that rollwise traverse would be impossible. In the case of the pulp, we have found that tractive contact with a suitably rough surface may be readily obtained at relative tangential velocities of the opposed surfaces ranging between one hundred and fifty and three hundred feet per minute, but is more difficult to maintain at greater speeds. Pressures may range from light gripping contact to some twenty pounds or more per square inch of contact surface.

The "gyrational agitation" of the layer of pulp specified herein as a step of the process of our invention, is a distinctive type of very intense and thorough agitation which results when the working surfaces gyrate relatively to one another while they grip the layer of pulp in tractive contact. This "relative tangential motion of a gyratory character" is the same as that defined in our pending application Serial No. 674,672, filed June 6, 1946, now Patent 2,599,543. A preferred example of gyrational agitation is that in which one of the surfaces is stationary and the other gyrates in a manner such that all points on the surface describe circular paths of equal diameter. Suitable gyration amplitudes for the purpose are usually within the range of one-half to four inches, and gyration frequencies within the range of 200 to 2000 cycles per minute. The gyrational agitation thus produced causes profound physical actions and effects throughout the layer of nodulated pulp and throughout each nodule and each fibre, in a manner such that no fibre can escape the action. A special feature of the rollwise tractive contact between the surfaces and the pulp is that the surfaces and the perforations therein are thus made self-clearing and self-cleaning with respect to accumulations of pulp fibres, as would not be the case with a frictional-slipping or grinding contact.

When we specify an "excess of liquid" provided in the layer of pulp under action, we mean that there is to be an excess of liquid over what the layer of pulp can hold under the degree of compression which is employed. Such a condition of excess liquid may be obtained in several ways. Thus, the excess may already be present or added to the pulp before its compression. This would be the case for example if the starting pulp consistency were low, say at 4%, and then while under the action as specified, a light initial compression were gradually increased, with the result that there would be a continuous excess of liquid as long as the compression was increasing with the layer of pulp attaining gradually increasing consistency, say up to 25%. Or, as is usually preferable, the excess liquid may be introduced separately and continuously to the layer of pulp under action, thus providing the condition of excess liquid necessary for carrying out our method. Water is the usual liquid agent although, as will be described, various aqueous solutions or other liquids may be employed for special applications of our method, without departing from its scope.

A fundamental condition of our method is that excess liquid should not only be present during the agitation of the layer of pulp but should also flow out of the pulp being agitated, for it is this outflow which carries with it the finer particles and finer fibres of the pulp which are freed from the larger fibres during the unique agitation in the presence of an excess of the liquid. Obviously the finest particles are in general the first to leave, but, by continuing the flow of excess liquid through and out of the pulp layer under continued agitation, progressively larger particles and fibres may be freed and removed, and fractionation cuts may be made on the effluent liquid to separate or select any desired fraction or combination thereof. Very close control of the fractionation is possible through regulation of the amount of liquid passed through and withdrawn from the pulp, and through choice of the time of agitation, and through the selected relationships of the flow and time factors. The consistency which is maintained in the agitated layer of pulp, as determined by the degree of its compression is also a convenient control factor. The size of the perforations of the surface, through which the effluent flows, as well as their number and arrangement, afford still other controls of the fractionation. The perforations may be holes or slots, or may be provided by other foraminous structures such as woven wire screens or by materials of porous structure which will permit passage of fluids to or from the working space where it is directly introduced to or removed from the material being processed between the surfaces. Thus, by the term perforated surfaces as used in the disclosure and claims, we mean surfaces having through them multiple passages of the general types described.

It is to be understood that all the fractions above referred to are not necessarily fibrous. Thus the pulp may contain certain fine non-fibrous constituents including those occurring naturally, such as pitch particles, and those present as contaminations and extraneous dirt particles, and those present as added material from some previous process, such as mineral filler and ink pigments in reused stock.

While the method of our invention may be demonstrated and carried out by a variety of apparatus, we prefer for continuous operation apparatus such as that shown in Figure 1 and more fully illustrated and described in our co-pending application Serial No. 674,671, now abandoned.

Referring to Figure 1, which is a sectioned elevational view of such an apparatus, we show at 1 and 2 two circular opposed, coacting plates mounted horizontally one above the other; for clarity of illustration, the space between them is much greater than the normal operating clearance. The lower plate 2 is mounted on the gyrating element 3 which may be given gyratory movement of the type herein described by the mechanism comprising the gyrating journal 4 cooperating with the journal bearing 5 which rotates with and is eccentric to the driving axle 6 driven by the drive shaft 7. The gyrating element 3 is supported and restrained from rotating by the universal joints 8, of which there are four, and the universal joints in turn are supported by the connecting rods 9 which connect to means providing controlled adjustment of the clearance between the plates 1 and 2 or, alternatively, means of controllably varying the pressure applied to the layer of stock in the working space. The upper plate 1 is mounted on the sta-

tionary element 10 which is supported on the circular housing 11 of the machine. Stock to be treated is fed through the central inlet feed connection 12 in the upper element and the stock discharges at the peripheral discharge zone 13 where the clearance between the plates 1 and 2 is reduced to give better control of throughput. The active working space of the machine extends radially between the central opening in the upper plate 1 which communicates with the inlet connection 12 and the discharge zone 13 at the periphery. A collecting channel 14 catches processed pulp dropping from the discharge zone 13 and conveys it to the opening 15 for removal from the machine. The working surfaces of plates 1 and 2, one type of which is illustrated in Figs. 2 and 3, are suitably rough textured or figured to provide a good degree of tractive contact with the layer of pulp, and in addition both surfaces are provided with perforations, indicated at 16, to permit a flow of liquid therethrough; perforations, which are suitable for many applications, are circular holes having diameters in the range of one sixteenth to a few thousandths of an inch, and spaced on about one-eighth inch centers over selected zones across the radial path of traverse of the stock through the working space. The perforations of the upper plate may serve as inlets to or outlets from the stock for the liquid, and are backed by header cavities 17, 18 and 19 to which liquid may be provided through the connections 20, 21 and 22. The perforations in the lower plate 2 serve as outlets for the flow of excess liquid as it leaves the layer of pulp, communicating with suitable collecting channels such as 23 and 24 from which the excess liquid is removed by flexible connections such as are shown at 25 and 26. The provision of the multiple inlet liquid connections 17, 18 and 19 leading to separate, radially spaced bands of perforations, and the similar arrangement of liquid outlet connections in the lower plate 2, permit the use of a variety of liquid flow patterns as noted hereinbelow. Counter-current flow of liquid and pulp stock may be obtained by appropriate cross connection of inlet and outlet headers, or successive treatments with different liquids may be applied to the pulp during its radial traverse across the working space.

In Fig. 2 we show in plan, and in Fig. 3 in sectioned elevation, both to enlarged scale, one of the many possible patterns in which the working surfaces of plates 1 and 2 may be formed to provide suitable traction and drainage characteristics. In both Figs. 2 and 3 we show at 27, small, raised tetragonal pyramids, with bases about 0.030 inch along the sides, 0.025 inch in height, and with approximately 0.030 inch spacing between facing bottom edges of adjacent pyramids. At 16 we indicate perforations for liquid throughflow which, for some applications of our method, may be about 0.020 inch in diameter.

The following description illustrates the functioning of our method in conjunction with this machine. With the plates in their operating position and the bottom plate gyrating, a flow of pulp is positively fed to the working space through the central opening in the top plate, using any convenient feeding means such as a pump, screw press, screw conveyor, etc. The rate of throughput is controlled by the relationship between the feed pressure and the clearance at the periphery. If the additional feature of a pulsating clearance is provided, this also provides an excellent control of throughput. With a layer of pulp progressing continuously through the machine under gyrational agitation as described, a slow flow of water is caused to pass from the top plate through the agitated layer of pulp and out through the bottom plate. As noted, the rate of the water flow is one of the important controls of the rate of selection and removal of the finer pulp constituents, and the flow is determined by the pressure differential which is maintained between the inlet and outlet headers. It will be apparent that this pressure differential may be that between two positive pressures or between a positive and a negative pressure, with respect to atmospheric pressure. It will also be apparent that the water inlet pressure must bear a suitable relationship to the pulp feed pressure, and also to the amount of compression which is used on the layer of pulp. In general, where the flow of excess liquid is largely from inlets in one plate to directly opposite outlets in the other plate and the liquid flow path between the plates is little longer than the thickness of the pulp layer, very small pressure differentials are adequate to force the required volumes of water through the pulp layer. These differentials are generally less than one pound per square inch due to the thinness of the pulp layer, the nodulated condition of the pulp layer, and the intense agitation provided by the gyratory action. Because these pressure differentials are small, while the absolute pressures may be much greater, we prefer to directly control the wash water flows by the use of valves and flowmeters or by the use of variable speed positive displacement pumps, rather than to attempt direct control of the pressure differentials.

The outflowing water from the bottom plate, carrying with it finer materials from the pulp, may be handled as a single stream for disposal or recovery, or it may be piped away from the plate as two or more streams representing the separate flows from selected radial zones of the plate and therefore containing different size classifications of the pulp constituents, ranging from finest nearer the center of the plate and coarsest nearer the periphery. Other convenient controls of the size differences of the fractions in such streams are the relative size of the perforations in the respective zones, and the rate of the flow of water as separately controlled at selected zones.

The method of our invention may be used in a variety of operations where separation of different sized constituents of a pulp or a pulp mixture is an object. Once the principal features of the invention are understood and recognized, a growing list of applications will be apparent to those skilled in the art. We describe below several different applications as illustrating the usefulness and scope of our invention.

The separation of an undesirable fine fraction from wood pulp

It is well known that a chemical pulp may be considerably improved with respect to strength properties, color, cleanliness, bleachability, pitch and other purity factors, by the removal of a small fraction consisting of the finer sized constituents. This is accomplished in ideal fashion by the method of our invention, which not only performs the operation very efficiently and under close control but also, at the same time, greatly improves the pulp in many other respects along the lines described in pending application Serial No. 565,128, now Patent No. 2,516,384, granted

July 25, 1950. This purpose is conveniently accomplished by employing our method substantially in the manner and with the apparatus above described. Conditions are arranged and controlled so that a single small fraction is separated, usually ranging from 10% down to several percent as desired. This fraction will contain the pitch cells, short fibres, fibre debris, fine grit and dirt, etc. If extreme pulp purity is required for special purposes, the water used in our method may contain added specific agents or detergents for the purpose. Very greater efficiency and economy is possible in such cases, due to the small volume of water required and the intense and thorough scrubbing action on the individual fibres.

The separation of an undesirable coarse fraction from wood pulp

Applied to this purpose our method performs the usual functions of pulp screening. By providing relatively wide clearance in the main working space, but a suitably close one at the pulp outlet zone to control throughput, and a relatively low compression of the pulp, and a relatively large flow of water through the layer of agitated pulp, the main fibre classifications of the pulp may be progressively carried through suitable sized perforations in the working space, leaving in the working space a fraction composed of a progressively larger proportion of the undesirable oversize constituents of the pulp which is discharged at the pulp outlet zone of the working space. This larger size fraction, for example, might consist of the so called "knots" and "shives" present in unscreened pulp, or extraneous matter in repulped waste paper.

Simultaneous liberation and fractionation of fibres from a fibrous substance

Applied to this purpose the method of our invention in effect carries out very effective fibre liberation under screening conditions, so that as soon as the fibres are liberated from the fibrous substance, they are removed from the zone of action and thus are preserved from over-treatment while more resistant portions of the material are being reduced. In this way also, the working action is always directed to unreduced material thereby greatly increasing efficiency with respect to power, capacity and rate of reduction as compared with the usual case where there is no separation during the action. There is also afforded the opportunity, as has been described, for the final separation of an oversize or over-resistant fraction at the end of the operation.

This type of operation is particularly useful in connection with so called high-yield or semi-chemical pulping of wood or other fibrous material. Thus, fibrous material in a suitably subdivided form, such as wood chips, chopped straw, etc. may be softened by any convenient cooking and chemical treatment and then fed between the relatively gyrating working surfaces. In some cases the softening treatment may be carried out between the working surface utilizing a selected preliminary zone of the working space and introducing heat and softening agents as required. In any case, the softened material is gripped and compressed by suitably tractive surfaces and gyrationally agitated as described. Under this action fibres are liberated at a rapid rate and first form a part of the agitation layer, and then, as a flow of water is caused to pass through the layer, the freed fibres pass out through the perforated surface with the effluent liquid about as fast as they are liberated. Obviously, the less resistant material is defibred and removed first, and using the continuous apparatus described, this will occur near the centre, while the increasingly resistant material traverses progressively further towards the periphery, where the final cut of undesirable material may be made as has been described. It is apparent also that other fractions could be selected at intermediate zones if desired.

De-inking of printed, waste paper

In a similar way the method of our invention provides a novel and very efficient unit-type process for the de-inking of printed, waste paper. In this case, waste paper partially disintegrated (as by hammer milling) is fed with water to the working space between relatively gyrating surfaces as described. A compressed layer of the material is thus formed and gyrationally agitated, and a flow of water is caused to pass through the agitated layer, whereby two highly desirable results are obtained simultaneously. First, the paper is completely repulped to individual fibres, and, second, the ink particles are freed from the fibres, and are removed to any desired degree in the flow of water. Relatively small amounts of water are required, and remarkable results of cleaning are readily obtainable on some types of printed papers using cold water alone. Thus, by the use of our method and suitable apparatus, we have produced high-quality, bright, de-inked stock from mixed magazine papers by the use of only three gallons of water per pound of stock, in distinction to the twelve to fifteen gallons ordinarily used in the known de-inking processes. When still further efficiency or degree of treatment is desired, recourse may be had to the use of well known de-sizing, detergent or bleach materials added to the water with or without the use of higher pulp temperatures. In de-inking, where we wish to remove the very small ink particles while retaining the relatively large fibres, we provide smaller perforations than in the preceding cases where the removal of part of the fibres was an object.

By the term "detergent material" we mean the general class of substances which are effective in separating and dispersing ink particles from fibres, such as sodium hydroxide, sodium carbonate, sodium silicate, trisodium phosphate, soaps, emulsifiable oils, specific surface-active agents for promoting wetting, foaming, emulsifying, etc., or combinations thereof. It may be noted that the gyrational agitation of the layer of pulp is very effective in producing emulsions or foams directly in the layer, where this condition is desirable for superior cleaning results. In this connection, it may be noted that while many kinds of printed papers, particularly magazine-type papers may be de-inked by the method of our invention using water alone as a washing medium, the efficient application of the method to printed newspapers usually requires the use of a detergent material, such as soap, in the wash water.

By the term "bleach material" we mean the general class of substances which are effective in brightening pulp, such as sodium peroxide, hydrogen peroxide, sulphur dioxide, hypochlorous acid, hypochlorite, etc.

It is found that excellent results are obtained by the use of very small amounts of such added materials, so that in many cases no subsequent

washing of the pulp is required other than that of its normal dilution to paper making consistencies. If, however, special washing is required in some cases, this may readily be accomplished as a unit operation with de-inking in a machine of the type described by introducing a short, fresh water, washing zone in the final stages of the stock traverse path through the working space. Here again, owing to the high consistency and the unusual efficiency of the agitation, only a very small volume of wash water is required. By the use of our method for de-inking it is therefore now possible to accomplish in a unit operation in a relatively small apparatus with a relatively small amount of water or special agents and in a time interval of a few seconds to a few minutes, what has formerly required numerous separate operations, large accumulations of cumbersome equipment, large amounts of water, power and special agents, and an elapsed time that might amount to six to ten hours, and to obtain by our invention much superior products. Obviously, if desired, separation of the pulp into selected fractions may be effected along with de-inking, by making suitable division of the working surface with respect to the outflow-perforations and segregating the effluent therefrom, as desired.

It will be apparent that the de-inking application of our invention may be similarly applied to a waste printed paper stock which has already been essentially repulped by gyrational action or other means, such as a beater, jordan, disk refiner, etc., using our present method for the separation of the ink particles, or of other fractions, from the stock as described.

Repulping of waste paper and broke

Still another application of the method of our present invention is for the repulping of unprinted waste paper or broke with simultaneous fractionation according to particle and fibre size, and this may be readily accomplished by the techniques and apparatus hereinbefore described. Thus for example a mixed, waste paper stock supply may readily be separated into two or more grades of cleaned and perfectly defiberized pulp with the higher grades often of a premium quality, alone more than enough to cover all costs. Here also, detergent and bleaching agents may be added to the liquid for special cleaning effects.

Washing soluble materials from pulp

Closely related to the above described applications of our method, is that of washing a soluble material from a fibrous pulp, and our general method is very effective for this purpose. It is found that a relatively very small amount of wash water flowing progressively through a compressed, gyrationally agitated layer of pulp will remove any water soluble substance with a high degree of speed and thoroughness. This great efficiency is accounted for in part by the profound agitation produced throughout every part of the layer of pulp and by the continual flexing and manipulation of each individual fibre, together with the favorable factor of high pulp consistency. Thus, in our method each fibre is held under control and very actively washed, as compared with a more or less uncontrolled, passive, soaking type of washing which the individual fibres receive in other known pulp-washing operations. When pulp washing is the only object, without removal of an appreciable fraction of fibrous material, it is usually preferable to provide small perforations in the working surfaces and to use relatively high consistencies in the agitated layer of pulp, and a relatively small flow of water.

Our present washing method is of further advantage for washing operations where an accompanying object is the recovery of soluble material, for example, in the recovery of spent "cooking" liquor in "kraft," "soda," and "sulphite" pulping operations. In such cases, our method permits higher total recoveries of solubles with less dilution than by any hitherto known method, and at the same time effects improvements of the pulp as described.

Removing water from pulp

As has been noted, excess water in the original pulp stock may be readily and progressively removed by increasing the compression of the layer of gyrationally agitated pulp, the excess water flowing through the perforated working surface in contact therewith. Utilized in this way the method of our invention provides a novel and very effective way of thickening or dewatering an aqueous pulp suspension or slurry. Thus it is easily possible by this method to raise a pulp consistency from 3% to 40% at a very high capacity rate in terms of area of drainage surface, as compared with that obtainable with conventional filters and pulp thickeners. A favorable factor in the efficient performance is the self-clearing and self-cleaning nature of the tractive, rollwise traverse of the pulp over the drainage surface. Another factor is the intense agitation which prevents any stratification of finer material which might slow up drainage. Still another factor is the characteristic, very complete nodulation of the pulp as caused by the gyrational agitation. As is well known, a nodulated pulp is faster draining than the same pulp in a felted, non-nodulated state. When the main object is dewatering, with a minimum removal of fine solid constituents, it is preferable to use relatively fine perforations of the working surface. Obviously, however, any of the other pulp fractionations as described herein for our method, may be carried out in conjunction with the water removal object.

It is to be noted that the increasing compression of the pulp, which is specified as a requirement in the water-removal application of our method, is obtained not necessarily by decreasing the clearance between the opposed surfaces, although it may be so obtained. In continuous operation, an increasing compression of the pulp is readily obtained by means of the pulp feed pressure, using this to force pulp into the entry zone of the working space between the opposed surfaces, and arranging a suitable restraint of the flow of pulp at the outlet zone. It will be found that the compression of the pulp, that is, of the mass structure of pulp fibres, increases across the working space, although the hydraulic pressure may be virtually constant, or may diminish across the working space. The herein described added feature of a pulsating compression, as caused by a cyclical variation in the clearance between the working surfaces, is a particularly effective means of control for the continuous dewatering application of our method.

In the above descriptions we have dealt primarily with water or aqueous solutions as the liquid agent to be used in our process. Obviously, however, other, non-aqueous, liquids may be employed for special purposes, without departing from the spirit of our invention. For example, specific solvents for certain pulp or waste paper

ingredients might be employed for extracting those ingredients by our method, the effluent liquid carrying with it as well any desired fraction of fine insoluble constituents.

While the gyrational agitation of the layer of pulp as described is a fundamental feature of our invention, the method may in some cases be still further improved by causing, in addition to the gyrational agitation of the layer, a regular pulsation of the compression of the layer, obtained by imparting a regular cyclical variation in the mutual clearance of the working surfaces in addition to their relative tangential motion of a gyratory character. This pulsation of the compression of the layer still further increases the intensity and thoroughness of the agitation and thus in turn increases the efficiency of the various process effects dependent on this agitation, such as the progressive washing out of fine constituents or soluble material in the repulping of waste paper, the liberation of fibre from fibrous material, or the de-inking of waste paper, etc. In the case of continuous processing by our method in the manner described, the regular cyclical variation in working clearance is also an important further aid in promoting and controlling the flow of stock between the working surfaces in response to the stock feeding pressure.

The pulsating variation in the clearance of, or the compression by, the surfaces may be obtained by known mechanical means actuating the movement of one surface towards and away from the opposing surface. Hydraulic means, however, are usually the most convenient and an example of such means has been described in detail in our pending application Serial No. 705,540, filed October 25, 1946. The pulsating variation in clearance between the surfaces for this purpose is relatively small, being usually under one-quarter of an inch and often much less. The frequencies of the pulsations which may serve for various applications of our method may cover a considerable range, for example, from 10 to 200 cycles per minute.

In regard to the flow of liquid which, as a characteristic of our method, is caused to pass from the gyrationally agitated layer of pulp, it will be apparent that this may be arranged in a variety of ways without departing from the scope of our invention. Thus, the flow may be steady or intermittent; it may vary in rate at selected zones of the working space; the inflow and outflow may occur at the same working surface, or at the opposed surfaces respectively; or the flow may be substantially transverse, from directly opposed inlet and outlet zones. The flow may also be directed in a course somewhat laterally through the layer by placing the inlets and outlets in separated zones along the line of traverse of the layer of pulp. In this way, if desired, a degree of counter-current flow of liquid agent and traversing pulp may be achieved. Counter-current action may also be achieved by returning the outflow from a later zone of pulp traverse to serve as the inflow of liquid at an earlier zone, repeating this if desired, and removing the final effluent near the start of the pulp traverse. Other arrangements and combinations for particular purposes will be obvious to those skilled in the art.

We claim:

1. A method of removing water from an aqueous slurry of a fibrous pulp which comprises forming and compressing a layer of the slurry of pulp between and in tractive contact with two opposed surfaces, gyrationally agitating said layer by imparting to said opposed surfaces relative tangential motion of a gyratory character while maintaining their tractive contact with and their compression of said layer, increasing the compression of the agitated pulp whereby excess water is caused to flow therefrom withdrawing the water through one of the surfaces, and continuing to increase the compression of the pulp and to agitate it gyrationally until a desired fraction of water has been removed from the pulp.

2. The method of de-inking printed paper which comprises traversingly rolling printed paper stock between two opposed working surfaces in different directions relative to those surfaces while the stock is under compression by and in tractive contact with said surfaces and while passing water through the stock.

3. The method of fractionating papermaking pulp which comprises forming the pulp into small, moist nodules, compressing a thin layer of said nodules between opposed working surfaces, and, while they are compressed, rolling them about traversingly in different directions over the working surfaces, and simultaneously passing a liquid through the layer of nodules to wash away finer constituents of the fibrous material.

4. The method of de-inking printed paper which comprises partially disintegrating the printed-paper, forming small, moist nodules from said disintegrated paper, compressing a thin layer of said nodules between opposed working surfaces, and, while they are compressed, rolling them about traversingly in different directions over the working surfaces to separate the ink particles from the paper fibres, and simultaneously passing a liquid through the layer of nodules to wash away ink particles.

5. The method of de-inking printed paper stock which comprises disintegrating the paper stock while dry, feeding the disintegrated stock with water between two opposed working surfaces, compressing the stock between the two surfaces, and, while maintaining the stock under compression, rolling the stock tractively in traverse of and under compression by the surfaces and simultaneously passing water through the stock.

6. The method of de-inking printed paper stock which comprises disintegrating the paper stock while dry, feeding the disintegrated stock with water between two opposed working surfaces, pressing the surfaces toward one another to compress the stock between them, and, while maintaining the stock under compression, imparting a gyratory translatory motion to one of the surfaces about an axis extending in the direction of compression to form nodules of stock and to roll the nodulated stock in continually changing direction tractively in traverse of and under compression by the surfaces, and simultaneously passing water through the rolling stock.

7. A method of fractionating papermaking pulp which comprises compressing pulp between and in tractive contact with two opposed working surfaces, moving the surfaces relative to one another with a relative translatory gyratory motion about an axis extending in the direction of compression while maintaining tractive contact of the surfaces with the pulp and compression of the pulp, thereby to roll the pulp traversingly in continually changing directions on and across the working surfaces, providing an excess of liquid in the pulp, allowing liquid to flow from the rolling pulp, and regulating the effluence of liquid so that the effluent liquid carries with it rela-

tively finer constituents of the pulp, and continuing the rolling movement and compression of the remaining pulp and the flow of liquid therefrom until a desired fraction of finer constituents has been removed from the pulp.

8. A method of fractionating papermaking pulp which comprises feeding pulp between two opposed working surfaces at one boundary thereof, compressing the pulp between the two surfaces, moving the surfaces relative to one another with translatory gyratory motion about an axis extending in the direction of compression while maintaining compression of the pulp and tractive contact of the pulp with the surfaces, thereby to roll the pulp traversingly in continually changing directions on and across the surfaces, providing an excess of liquid in the pulp during its rolling movement, and withdrawing liquid from the pulp at different points along the path of travel of the rolling pulp from the inlet boundary of the surfaces to the discharge boundary thereof, whereby the out-flowing liquid may carry with it different constituents of the pulp at different zones along the path of said rolling travel of the pulp.

9. A method of fractionating papermaking pulp which comprises forming and compressing a layer of pulp between two opposed working surfaces, gyrationally agitating said layer of pulp by imparting a gyratory motion to one of said surfaces about an axis extending in the direction of compression, causing a pulsation of said compression of the pulp, providing an excess of liquid in said layer of pulp while it is being agitated, withdrawing liquid from the agitated pulp through one of the surfaces so that the outflowing liquid carries with it relatively finer constituents of the pulp, and continuing the gyrational agitation and pulsating compression of the pulp and the flow of liquid therefrom until a desired fraction of finer constituents has been removed from the pulp.

10. A method of de-inking printed paper stock which comprises compressing a layer of stock between two opposed working surfaces, gyrationally agitating said layer of stock by imparting relative translatory gyratory motion to said surfaces about an axis extending in the direction of compression while maintaining tractive contact of the stock with the surface and compression of the stock by the surfaces whereby the ink particles are liberated from their bonded contact with the paper fibres, providing an excess of liquid in said layer of stock while it is being agitated and compressed, and withdrawing liquid from the layer of stock to carry away the liberated ink particles with the outflowing liquid, and continuing the agitation and compression of the stock and the withdrawal of liquid therefrom until the desired fraction of ink particles have been removed from the stock.

11. A method of separating a soluble fraction from papermaking pulp which comprises forming the pulp into small, discrete nodules, compressing the nodulated pulp between two opposed working surfaces, rolling the nodulated pulp traversingly on and across said opposed surfaces while maintaining tractive contact of the surfaces with the pulp and their compression of the pulp, providing in the nodulated pulp, during rolling movement thereof, an excess of a liquid which is a solvent for the soluble fraction in the pulp, withdrawing liquid from the rolling pulp through one of the surfaces during the rolling traverse of the pulp on and across the surfaces, and regulating the effluence of the liquid so that it carries with it a portion of the soluble fraction from the pulp, and continuing the traversing roll and compression of the remaining pulp and the flow of liquid therefrom until the desired portion of the soluble fraction has been removed from the pulp.

12. The method of processing papermaking pulp which comprises introducing the pulp between two opposed working surfaces at one boundary of said surfaces, traversingly rolling the pulp between the surfaces in different directions relative to the surfaces while the pulp is under compression by and in tractive contact with said surfaces, introducing liquid into and withdrawing liquid from the pulp during the traversing roll of the pulp on and across the surfaces, and regulating the out-flow of the liquid so that it flows out of the pulp at different rates in different zones of traverse of the pulp over the working surfaces between inlet and outlet boundaries of said surfaces.

13. The method of processing papermaking pulp which comprises introducing pulp between two opposed working surfaces, traversingly rolling the pulp between the two working surfaces in different directions relative to those surfaces while the pulp is under compression by and in tractive contact with the surfaces, and passing different liquids through the pulp in different zones of traverse of the pulp over the working surfaces from the inlet boundary to the outlet boundary thereof.

14. The method of processing papermaking pulp which comprises forming the pulp into small, discrete nodules, compressing the nodulated pulp between two opposed working surfaces, moving one of the surfaces relative to the other with translatory gyratory motion about an axis extending in the direction of compression to roll the nodulated pulp traversingly in continually changing directions between and in tractive contact with the surfaces, and, while effecting said rolling of the pulp and maintaining the compression of the pulp, passing liquid through the pulp.

15. The method of processing papermaking pulp which comprises forming pulp into small, discrete nodules, compressing the nodulated pulp between opposed working surfaces, and, while maintaining the nodulated pulp under compression, rolling the pulp traversingly between and on the surfaces, and simultaneously introducing a liquid into, and passing the liquid through the pulp.

16. The method of de-inking printed paper stock which comprises moistening the stock, forming the stock into small discrete nodules, compressing the nodulated stock between opposed working surfaces, and, while maintaining the nodulated stock under compression, rolling the stock traversingly between and on the surfaces, and simultaneously passing water through the stock.

17. The method of processing paper-making pulp which comprises placing an aqueous slurry of pulp under compression between two opposed working surfaces, rolling the pulp traversingly between and in tractive contact with the surfaces, and, while effecting said rolling movement, increasing the compression of the pulp to force excess liquid out of the pulp, and regulating the effluence of said liquid so that only liquid and fine debris can flow out of the pulp.

18. The method of processing paper-making pulp which comprises placing the pulp under

compression between two opposed working surfaces, rolling the pulp traversingly between and in tractive contact with said surfaces while the pulp is under compression between the surfaces, and simultaneously supplying an excess of liquid to the pulp, and withdrawing liquid from the pulp, and regulating the effluence of the liquid so as to prevent flow out of the pulp of anything but liquid and fine debris.

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