May 7, 1957 M. G. LYON ET AL 2,791,503

PROCESS FOR PRODUCING SEMICHEMICAL PULP

Filed May 8, 1952 2 Sheets-Sheet 1

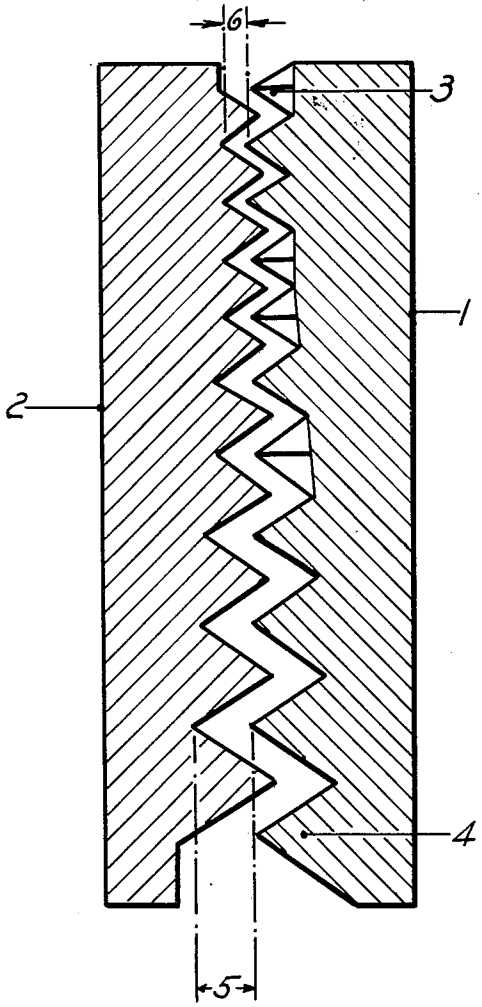


FIG. 1

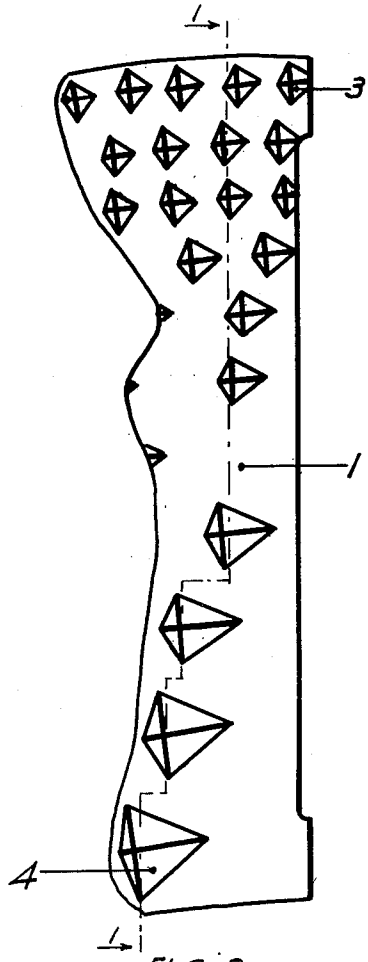


FIG. 2

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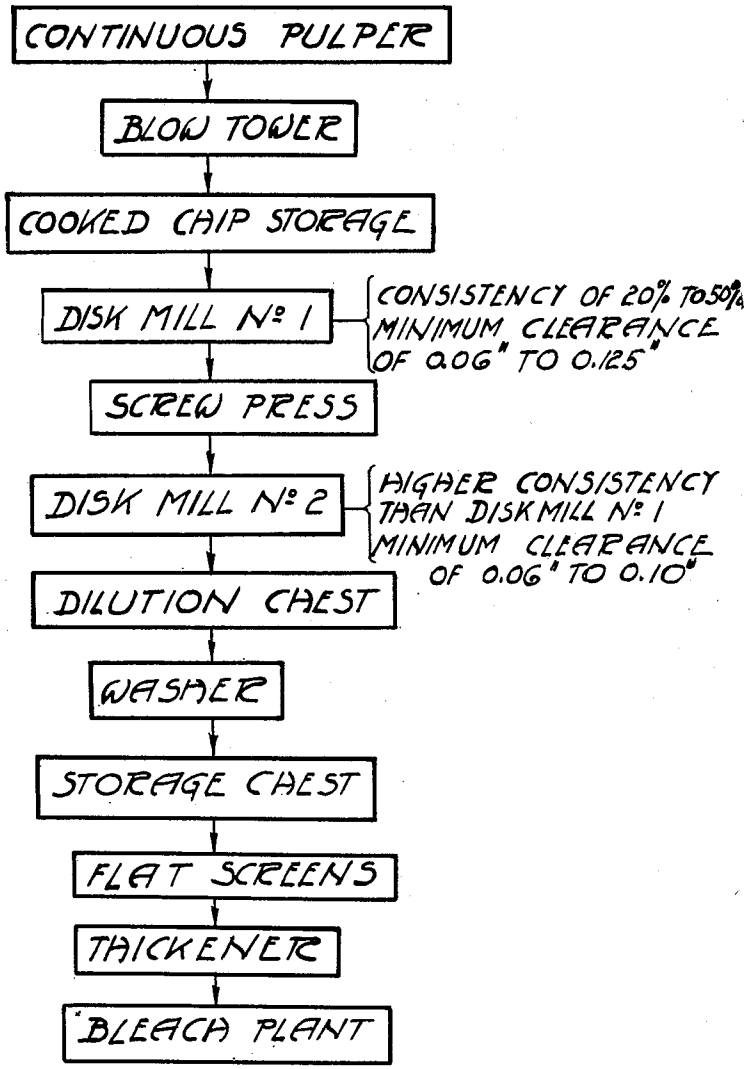


FIG. 3

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PROCESS FOR PRODUCING SEMICHEMICAL PULP

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Application May 8, 1952, Serial No. 286,694

2 Claims. (Cl. 92—6)

This invention relates to a method of preparing semichemical wood pulp. In particular it relates to a method of disintegrating and defibering the cooked chips to produce a pulp which is substantially free of shives and can be bleached to a high brightness with an improved retention of freeness.

In the semichemical process wood chips, or other lignocellulosic material in suitably subdivided form, are digested in a chemical liquor such as soda, sulfate, or neutral sodium sulfite process liquor, until the chips are partially delignified and suitably softened. They are then mechanically defibered into pulp. In contrast the regular chemical pulps are cooked until the fibers and substantially completely liberated and require little or no mechanical action to separate the fibers, one from the other.

The advantages of semichemical pulps are very valuable to and well known by the industry. The unbleached pulp yield, basis wood cooked, may be as high as 85% and usually at least 60%, as compared to yields of 40% to 45% for fully cooked pulps. The semichemical process permits the use of various woods, particularly hardwoods, that were previously considered unsuitable for strong pulps. As a result, much more efficient use can be made of the available wood; hardwoods can now replace more of the conifers as pulpwood. This is important because of the great expansion of the pulp and paper industry in recent years and the corresponding scarcity of supply, as well as greatly increased cost of wood. Another very desirable advantage is that semichemical pulps permit higher paper strengths to be developed at lower power expenditure than other pulps. In some instances semichemical pulp from short fibered wood, particularly from hardwoods, will produce a better, stronger sheet than a long fibered fully cooked pulp.

While the production of semichemical pulps has increased greatly, the expansion for the most part has been in the unbleached grades for the manufacture of automotive and flooring felts, wall board, box boards, corrugating papers, etc. In such products the appearance of the pulp is not critical. The exploitation of semichemical pulps as a bleached, high quality material suitable for writing and book papers has been retarded, due to certain inherent characteristics. A pulp to be satisfactory when bleached to a high whiteness (that is, having a brightness of from 70 to 85 and above, G. E. reflectometer) must be completely defibered, uniform, and free of shives and other foreign matter. If not suitably and completely freed of shives and the like, the bleached pulp will have a dirty, low quality appearance in spite of the whiteness of the pulp in general. If not uniform, and well defibered, the pulp can not be bleached satisfactorily. Only at the expense of over-bleaching the individualized fibers can the shives be brought up to whiteness.

Semichemical pulps do inherently contain a large amount of shives. Since the cooking is carried only part way in order to secure the high yield, considerable lignin is still present and there is a resistance to the mechanical

separation of one fiber from another. Interrelated with this is the pronounced tendency of semichemical pulps to hydrate and lose freeness, much more rapidly than fully-cooked pulps. Studies indicate that this is due in a large measure to the hemicelluloses retained. Semichemical pulps hydrate at a rate proportional to their hemicellulose content. If the pulp is cooked well, to a low yield (e. g., 50%), there is both less mechanical force required and less tendency to hydrate; the reduced amount of lignin left in the pulp reduces the resistance to defibering, and the shive content, and there is less hemicellulose in the pulp. But in previous attempts to cook to a high yield, and then completely defiber the semichemical pulp to a uniform degree suitable for bleaching, the mechanical energy applied has lowered the freeness excessively. It is recognized in the industry that the greatest problem confronting bleached semichemical pulps is that of securing a shive-free pulp without loss in freeness. The pulps have either been high in freeness and poor in quality due to inadequate mechanical treatment, or low in freeness because excessive mechanical action was employed to remove the shives. There has been little success in producing a bleached, shive-free semichemical pulp of high freeness. Rather it has been taken for granted that where bleached semichemical pulp is to be used in the papermaking furnish, the amount added must be limited to a fraction of the total pulp, or otherwise the machine speed must be decreased substantially to compensate for the slow rate of drainage on the wire and to avoid breaks in the web which interrupt manufacture.

Another difficulty which confronts the industry, as regards bleached semichemical pulps, is the fact that the bleaching operation itself adversely affects the freeness. For example, one semichemical pulp had a freeness of 546 cc. and 252 cc. for 0 and 100 minutes ball milling respectively before bleaching, and after bleaching its freeness for the two ball milling periods was 302 cc. and 119 cc. In an extreme case a high-yield semichemical aspen which had been deshived with a large amount of work expended in a conventional disk mill had an unbeaten, unbleached freeness of 498 cc., and after bleaching to 76 brightness, its unbeaten bleached freeness was only 126 cc. Such a severe loss in freeness limits its use greatly. In order that a pulp can be used in any substantial amount in the furnish, it is necessary that it have a substantial retention of freeness after beating; a freeness of at least 200 cc. after 100 minutes in the ball milling test is preferred.

It is an object of this invention to provide an improved method of defibering semichemical chips.

It is also an object to provide a method of effectively defibering wood pulps without adversely affecting their papermaking properties.

It is a principal object of this invention to provide a method of defibering and deshiving semichemical pulps with a minimum of reduction in freeness.

It is a further object of this invention to provide substantially shive-free semichemical pulp in high yield which has an improved freeness after bleaching.

We have discovered that if a particular set of operating conditions is maintained throughout the process of passing semichemical chips between coacting mechanical surfaces, hydrating, cutting, bruising, and injury in general, to the fibers are substantially eliminated—yet, at the same time, the chips are substantially completely separated into well-defined, individual fibers, permitting the production of a bleached pulp containing no objectionable amount of shives and having improved retention of freeness. We have found there is a combination of a particular range of clearances between the coacting surfaces and a particular range of stock consistencies, where defibering is carried to an economical yield, yet with so little hydrating

and formation of mechanical debris that the freeness is still high after bleaching.

Our invention will be illustrated by particular reference to the accompanying drawings.

Figure 1 is a sectional view of a portion each of the top and bottom plates of a disk mill of the type having intermeshing projections.

Figure 2 is a plan view of a portion of plate 1.

Figure 3 is a flow diagram of a preferred form of our method of defibering semichemical chips in a continuous manner.

A great number of different types of equipment have been used to convert semichemical chips into pulp but so far as we know the problem of retaining freeness when the pulp is completely defibered has not been solved. For example, rod mills have been used for semichemical pulp but only for relatively coarse pulp. It has been suggested that if a rod mill is run at a consistency of 15% to 30% freeness is not greatly reduced. However, in the cascading of the rods as the mill rotates a positive impact of one rod against the other occurs, which tends to mash and damage those fibers which are trapped between impinging rods. This may not show up immediately in freeness loss but will be very pronounced after bleaching. Also, the conditions in a rod mill are such that the stock (chips and fiber bundles) is not confined but tends to escape from the interacting rods. Consequently, the efficiency is low. The rod mill must be followed by a disk mill, jordan or other equipment to complete the defibering. In fact, the use of rod mills in the pulp industry is giving way to disk mills and similar apparatus which are more positive in their action.

Disk mills have been extensively used in the semichemical process and many different plate designs have been tried. These mills have been designed to operate at very close clearances; for example, in the conventional operations the chips are initially passed through the mill at what is considered to be rather large clearance, namely, from 0.010 to 0.020 inch, and then to complete the deshiving at plate clearances of from 0.001 to 0.003 inch. In fact, it is not uncommon to set the plates at a clearance of only 0.003 to 0.005 inch during the chip breakdown. At the high speeds of rotation employed in disk mills, there is a tendency for a rotating plate to vibrate or waver; equipment manufacturers go to considerable effort to design and so construct the disks as to prevent this and to permit the plates to be operated at these clearances of only a few thousandths. These very close clearances have been regarded as being highly necessary to adequate defibering.

We have found that these extremely close clearances are harmful and undesirable; furthermore, they are unnecessary to adequate defibering. Apparently where there is positive impact, or even near physical contact, of one mechanical working surface against another, whether it is rod against rod, bar against bar, or plate against plate, detrimental physical forces are exerted on the stock causing excessive loss in freeness before the fibers are well separated.

According to our invention, the spacing at the closest point between two coacting mechanical surfaces is at least 0.06 inch; complete defibering is secured at such spacing provided certain conditions of high stock consistency are employed. This is unexpected inasmuch as individual wood fibers are, on the average, only 0.0006 to 0.0017 inch in diameter and it would seem that the coacting mechanical surfaces would have no effect on the fiber bundles suspended in water when at such spacing as we employ.

In the present invention consistencies, including consistency of the chips at the beginning of the defibering, in the range of from 20% to 50%, and plate clearances of at least from 0.06 to 0.25 inch at the closest point are maintained. Under these conditions the stock can move between the intermeshing projections as a fluid and there is no opportunity for positive solid to solid impact of an injurious nature. Yet due to the high consistency of the stock, the projections do exert sufficient force upon the stock to separate fiber from fiber.

While our process may be carried out in various types of machines having coacting mechanical elements, a disk mill of the type in which the projections, or teeth, on one plate intermesh with those of an opposing plate, affords an efficient means of carrying it out. In Figures 1 and 2, the projections are more or less pointed pyramids in concentric rings suitably spaced to permit intermeshing with those on the opposite plate. However, the projections may also be other shapes such as hemispheres, cones, flat blades, and cylindrical pins. At the periphery small teeth 3 are used, while teeth 4 near the center of the plate are much larger. The teeth on plates 1 and 2 decrease progressively in size from 4 to 3, although the teeth in the rings near the periphery may be substantially the same size. The minimum clearance between plate 1 and 2 is indicated at 6 near or at the periphery of the disk. The spacing or clearance 5, toward the center of the disk may be equal to that at 6, but in most cases is considerably greater so there is a convergence in the passage as it approaches the periphery. In disk mills of this type, disks of from 24 inches to 48 inches in diameter having a large number of projections on the surface are employed, and are operated at high speeds, for example, from 800 to 3200 R. P. M.; the number of projections passing each other per minute may be from 2,000,000 to 15,000,000. The stock is fed through a center opening in one of the disks and in its outward, helical centrifugal flow is repeatedly interrupted and forced into and through the confines between two adjacent projections by a projection from the other plate. The net result is effective defibering of the stock under the combination of operating conditions set forth herein. The very great number of teeth passes per minute, afforded by such a disk mill, permit rapid and thorough defibering. Its high throughput and complete action make this type of disk mill preferred equipment.

While a clearance of at least 0.060 inch between the working elements is necessary in order to avoid hydration and damage to the fibers, nevertheless the clearance must not be too great or the energy applied would not be effective throughout the layer of stock. At the high consistencies we employ, working of the stock at clearances of as much as one to two inches, does accomplish defibering but the rate is low. Also, at the point where the chips are introduced, as at the center opening of a disk mill, the surfaces are usually an inch or so apart. Thus chip breakdown and intermediate working can be carried out at relatively wide spacings, particularly if the stock is under pressure. But where the ultimate defibering is being completed with separation of shives into individual fibers, whether in a disk mill or in other equipment, the clearance or spacing at the point of closest approach is usually not more than about 0.25 inch.

In order that the mechanical forces may be effective in defibering and deshiving the pulp at these relatively wide clearances, the consistency of the stock should be at least 20% and preferably from 30% to 50%. At consistencies substantially below 20%, the forces are not effectively applied and all the available fibers are not released; a large portion of the energy is dissipated in hydraulic shear, increasing the amount of horsepower required unduly. Furthermore, the tendency to hydrate is greatly increased at consistencies below 20%. On the other hand, if the consistency goes about 50% the stock acts as a dry, non-fluid mass; damage to the fiber and the formation of mechanical debris becomes very pronounced, with severe loss in freeness.

The effective working of the high consistency stock in our process is dependent upon mechanical elements which are capable of penetrating and acting throughout the heavy fibrous mass. Where the coacting ele-

ments are pyrimidal teeth as shown in Figures 1 and 2, they are preferably at least 3/16 inch high. The outer row of teeth 3 in the drawings are about 3/8 inch high and the larger teeth 4 are about 7/8 inch high.

While the process herein described has been illustrated by means of a disk mill, it can also be carried out by means of other equipment. We have found that disintegrators of the type consisting of a shaft or a rotor having a large number of spaced radial fingers rotating at high speeds within close fitting cylindrical casing can be effective. In one such machine, the inner surface of the casing has no projections, so that the coaction is between the casing and the radial pins or fingers. In another similar machine, the inner surface of the casing carries a large number of fingers intermeshing with the radial fingers on the shaft. In these disintegrators the stock is forced through the chamber under at least a slight pressure by a conveyor screw, pump, or the like. Yet another type of equipment we can use is a screw press having discontinuous flights, with resistors or projections on the inside of the casing which pass between the flights and through the breaks in the flights. In equipment of the various types mentioned, the projections whether they be flights on a screw, radial fingers, or other form are large enough to adequately interrupt and divert the flow of stock; they are usually at least a large fraction of an inch high in the radial direction and may be as much as several inches high.

It is also necessary in our process that the fibrous stock be suitably confined and restricted in its flow so as to permit work to be done on the fiber bundles. It must be held back in its general course or confined, sufficiently to permit a power input of from about 2 to 10 total expended horsepower per daily ton of pulp for chip breakdown to deshiving inclusive. Thus, in a disk mill of the type shown in Figures 1 and 2, the teeth 3 are sufficiently numerous, closely spaced, and suitably staggered as to prevent any escape of stock to the periphery without undergoing considerable working; the numerous teeth plus the convergence of the passage between the plates creates the necessary pressure. Restraining of the stock so as to prevent it from escaping the force of the contra-moving projections can also be accomplished in other ways. If the defibering equipment is of the nature of a screw press the discharge can be through an orifice plate having several small openings. Or the discharge opening can be a suitably converging throat or one large nozzle-like opening. The actual size of such openings will depend upon the size of the particular piece of equipment and the rate of through-put. But the rate of feed, or manner of feed must be such that in effect the stock is under some pressure and extruded from the defibering equipment. It might be said that in the process of the present invention, deshiving is accomplished by mechanical elements moving through a high consistency stock, under pressure or tightly confined, combing through it, churning it, and possibly setting up turbulent flow at the trailing edge of each projection.

Machines such as rod mills and over-lapping arm mixers have not been found suitable for our purposes. These and similar machines do not confine and compress the general mass or body of stock at a given instant so as to permit the stock to be worked under pressure; but instead such machines permit the stock to move away from a moving mechanical element so easily that relatively little working and defibering is accomplished. Similarly disk mills having grooved plates are unsuitable to the herein described process; the grooves provide channels for the ready escape of stock; grooved plates do not permit of intermeshing of the mechanical elements such as we have found necessary to adequately work high consistency stock and separate the fibers from each other without hydration; and unless the lands of the plates are set at the conventional close clearances of a very few thousandths of an inch, which clearances do result in shortening of the stock and hydration, adequate defibering is not accomplished.

Disk mills having intermeshing teeth not only are advantageous because of the large number of mechanical elements, high speed, and resultant high through-put but also for other reasons. They permit ready adjustment of the spacing between plates and adjustment in small increments. Also important is the fact that the plates, when suitably spaced as we have specified, still are close enough that they exert a positive, uniform action upon all the stock passing through the machine.

In carrying out our invention, the wood can be cooked by any of the usual semichemical processes wherein the chips or other comminuted lignocellulose, are partially cooked to the point where they are suitably softened to permit separation by mechanical means into well defined fibers. The cooking liquor can be of sulfate, soda, neutral sulfite, or other type. The cooking per se does not constitute our invention; cooking procedures for semichemical pulp are described in numerous places in the technical literature.

By way of illustration, the processing of a neutral sulfite semichemical pulp is given: A mixture of chips from several deciduous woods was cooked with a 4-to-1 liquor to chip ratio, applying 18% sodium sulfite and 3% sodium carbonate (both calculated as Na_2CO_3 basis dry wood); cooking cycle was 2 hours to reach 345° F. and 2.5 hours at 345° F. Unbleached yield, basis wood, was 65%. Such a cook is more or less conventional.

The cooked chips were drained, washed, and again drained; consistency at this point was approximately 30%. The chips in this condition were passed through a disk refiner having intermeshing teeth as shown in Figure 1, with a clearance of approximately 0.125 inch between the plates at the closest point (see 6 of Figure 1), and operated at 1760 R. P. M. The pulp discharged from the refiner was passed through a second identical refiner, also set at 0.125 inch clearance, at 30% consistency. The pulp at this point had a freeness of 628 cc. It was then screened at 0.35% consistency on an 0.008 inch slotted plate screen; screening rejects amounted to 4.2% of the weight of the pulp (dry basis). The screened pulp was bleached to a brightness of 85.7 (General Electric reflectometer) by a conventional three-stage chlorine, caustic extraction, calcium hypochlorite bleaching process.

The bleached pulp was tested by a standard laboratory bearing test wherein the pulp was ball milled for 100 minutes. Its properties were as follows:

	Beating Time (Minutes)	
	0	100
Freeness, cc.	479	244
Bursting Strength	148	308

It was completely free of any visible shives and had a uniform, white appearance. A sheet made from this pulp was soft and had little rattle, indicating little hydration. In comparison a similar neutral-sulfite semi-chemical pulp, bleached to 80 brightness, in which the chips were defibered by being passed through a disk mill at 6% consistency and .001 inch clearance, had a freeness of 517 cc. and 133 cc. for 0 and 100 minutes beating in the test ball mill. Such clearance and consistency are conventional in defibering semichemical chips for bleaching. Bursting strength was 213 and 333. Its appearance was poor due to the presence of a large number of fine foreign particles. A sheet made from this second pulp had a noticeable stiffness and rattle typical of a well hydrated pulp.

Our process readily permits obtaining of freenesses of over 200 cc. with fully bleached semichemical pulp after beating until maximum bursting strength is developed. This beating point corresponds to a laboratory ball mill-

ing of from 75 minutes to 125 minutes depending upon the species of wood. Thus, tulip poplar may be brought up to maximum bursting strength in 75 minutes ball milling while red oak requires 125 minutes or more. In general, pulps produced by our process have a freeness of at least 200 cc. at 100 minutes laboratory ball milling. The low freeness of 133 cc. given in the example is typical of the reduced freeness obtained by prior art methods carried out at low consistencies and close clearances.

It appears that in our process of defibering at very high consistencies and wide clearances, the chips or fiber bundles are subjected to a disintegrating action which is largely one of fiber against fiber, whereby a much milder though complete separation of the fibers is secured. A highly selective action occurs. Thus, fibers which have been suitably softened by the cooking are parted one from the other, without noticeable damage. The hard undercooked cores and other shives are, under these conditions, not subjected to the deleterious cutting and breaking action which occurs on the working surfaces at a clearance of only very few thousandths of an inch. Instead, the shives are left in such a form that they can be removed readily by screening. Moreover, our high consistency process of defibering takes place sufficiently rapidly that the amount of screenings, after one or two passes, will be small enough that no heavy load in reprocessing is encountered, and the yield will not be substantially reduced.

This selective separation of fiber from fiber in our process is highly important to bleached pulps. In the conventional defibering at clearances of 0.001 to 0.020 inch, the hard cores or bundles of fibers, and pieces of bark, cannot escape breakdown between the plates. As a result a large amount of hard fragments are produced which are small enough to pass through the screen slots. This fragmentized material for the most part cannot be bleached. As a result it is impossible to remove such foreign material either by screening or bleaching and an inferior pulp is obtained. In contrast our mild selective defibering permits these non-bleachable particles to be removed by screening.

Our process is conveniently regulated by carrying out the defibering to the point where the unbleached pulp will yield from about 2% to 6% of screening rejects on 0.012 inch slotted screen plates. If the screening rejects amount to more than 6% the defibering will not have been carried out to the ultimate in fiber release that can be obtained by our process. That is, pulp screenings or rejects would be returned for recooking or other reprocessing when at least part of the fibers are not in need of additional cooking. On the other hand, if the screening rejects are below about 2% it will be found that the foreign particles have been broken up into fragments which cannot be removed under commercial conditions by screening, bleaching or any other method, and consequently, the bleached pulp will have a non-uniform, dirty appearance. When the screening rejects are in the specified range, a clean shive-free pulp is obtained, provided the specified conditions of high consistency and relatively wide clearance are adhered to. Furthermore, the screenings obtained are of a coarse nature containing little if any acceptable fiber. Where the screening rejects are running 6% and above, the application of more mechanical force is called for. The pulp may be given an additional pass through the defibering equipment, the disks may be set closer, or the consistency raised. Where the screening rejects are below 2%, it is an indication that the disks are too close, or that the mechanical treatment is otherwise excessive.

To permit the desired results of a high brightness shive-free pulp of good freeness, an adequate amount of cooking is necessary. Semichemical chips cooked to an unbleached yield, basis wood, of from 55% to 70%, should be used. If the pulp has been cooked to a lesser degree, for example 75% to 80% unbleached yield, it will be highly difficult to complete the defibering into individualized fibers without undue hydration and fiber damage. Also this very high yield pulp is uneconomical to bleach to a high brightness, that is, in the range of 70 to 85 and above. While most hardwoods should be cooked to no higher than 70% unbleached yield, good results can be obtained with easy cooking woods, such as aspen, at somewhat higher yields. For unbleached pulp 75% yield is satisfactory.

It is essential to our process that the specified conditions of minimum clearance and of high consistency be maintained throughout the process wherever the fibrous material is subjected to severe mechanical forces between opposed surfaces. Loss in freeness and injury to the fibers can occur in the early stages of defibering, as well as in the ultimate deshiving. It is, therefore, as necessary to control chip breakdown as any other part. For best results, at the point of introduction of the chips and fibrous stock, the spacing of the projections on opposing surfaces should be relatively great. For example, as in Figure 1, the clearance between the plates at the center may be as much as ½ to 1 inch, and converge toward the periphery. That is, where whole or somewhat broken chips are being acted upon best results are obtained with proportionately large passages. The much closer settings and low consistencies employed in previous processes are avoided at all stages in our process.

Preferably our defibering process is carried out by using mild conditions initially and then increasing the severity of the treatment. Once the chips are more or less broken down the actual deshiving is best carried out at a consistency in the range of 30% to 50%. This heavier stock apparently is advantageous to the separation of the more tenaciously bound fibers without undue fiber damage and undue power consumption. The spacing between the mechanical elements usually should be at the lower end of the range, i. e., at about 0.125 inch to 0.10 inch, for the ultimate defibering.

The preferred form of our invention is shown as a continuous process in the flow diagram, Figure 3. Hardwood chips are cooked in a continuous tube-type digester, e. g., in a "Chemipulper," with a conventional neutral sulfite cooking liquor to a yield of 55% to 70%. They are then discharged into a blow tower and passed to a storage bin. The cooked and drained chips are fed from storage to a disk refiner of the type shown in Figures 1 and 2, having one stationary and one rotatable disk and having a center-feed inlet; through-put of pulp is about 20 tons per day. The disk mill can have two rotating disks, in which case the one is rotated in the opposite direction to the other. The chip consistency must be at least 20% and preferably 30% or over, while the minimum clearance between the surfaces is about 0.125 inch. After discharging from this mill the stock is thickened, with or without washing, to a higher consistency in the range of from 30% to 50%, and advantageously in the range of from 35% to 45%. Since a stock at a consistency in the range of 20% to 50% contains little, if any, fluid water that can be removed readily from the fibers by drainage or the like, the stock is best thickened by means of a screw press having suitable ports for the escape of expressed liquid. In a typical commercial size screw press the stock is compressed and is extruded through discharge openings of about ¾ to 2½ inch in size. An additional benefit is derived from de-watering by means of a screw press since, as mentioned previously, this type of equipment does exert the necessary type of action to defiber the stock, especially when resistors are interposed between the screw flights. After the stock has been thickened it is passed through a second disk mill of the type shown in Figures 1 and 2 to complete the deshiving, with the spacing between the plates set at about 0.125 inch. In the second case, the thickened stock was passed through the second disk mill at a setting of 0.065 inch. After the disk mill treatment, the stock in

each case was diluted to a 3% consistency, washed in a conventional manner, then diluted to a consistency of 0.35%, screened on a 0.012 inch cut screen plate, and bleached by means of a conventional chlorine, caustic extraction, hypochlorite bleaching process to a brightness between 70 and 86. The deshived pulps secured were of high quality, free from shives and having freenesses well in excess of 200 cc.

The coacting mechanical elements, in the various equipment suitable to the process, move relative to each other. In the case of a disk mill, one disk may be stationary and the other movable; if both disks rotate they may rotate in opposite directions, or in the same direction at different speeds. Similarly in other equipment, one set of projections may be stationary and the other movable, or both sets movable, but in any case are opposed and a relative movement exists.

While this invention has been described with particular reference to bleached semichemical pulps, the process also has utility and value in defibering pulp which is not to be bleached inasmuch as the better separation of fibers, less cutting and bruising, and better retention of strength and of freeness makes for an improved unbleached pulp for some uses.

Tests were carried out according to T. A. P. P. I. standards. The freeness results given were determined by T. A. P. P. I. standard T 227 M–49 by means of a Canadian standard freeness tester at 0.3% consistency. The ball mill processing of the pulp was carried out under a modification of T. A. P. P. I. standard T 224 SM–45, differing therefrom in that the charge of balls is 12 pounds ±2% and has a volume of 2140 cc., a charge of 167 grams of bone dry pulp made up to a consistency of 3.30% (total volume 5000 cc.) is used, and six 500 cc. samples are taken, at 0, 1500, 3000, 4500, 6000, and 7500 revolutions (0, 25, 50, 75, 100, and 125 minutes).

The word "shives" as used herein refers to fiber bundles, clumps, slivers, and other particles which are relatively large and unresponsive to processing, or in other manner are foreign in appearance from the individualized fibers.

The word "stock" as used herein refers to an aqueous slurry of the cooked chips and the fiber bundles and individual fibers separated from said chips.

We claim:

1. Method of preparing substantially shive-free semichemical pulp which comprises cooking hardwood chips to an unbleached yield, basis wood, of from 55% to 70%, passing the resultant stock at a consistency of between 20% and 50% under pressure between opposed, relatively moving surfaces exerting a combing action on said stock, said surfaces being maintained at a minimum clearance of at least 0.060 inch throughout the combing action, and the combing action continued until the rejects on a 0.012 inch cut screen are between 2% and 6%, the extent of cooking of the chips, the consistency of the stock subjected to the combing action and the combing action being so correlated as to produce a pulp having, after removal of shives and after bleaching to a brightness of at least 70, a freeness of at least 200 cc. as measured after ball-milling for 100 minutes, and removing the shives from said stock.

2. Method of preparing substantially shive-free semichemical pulp which comprises cooking hardwood chips to an unbleached yield, basis wood, of from 55% to 70%, passing the resultant stock at a consistency in the range of between about 20% and about 30% under pressure between opposed, relatively moving surfaces exerting a combing action on said stock, to partially defiber said stock, increasing the consistency of said stock to a value in the range of between about 30% and about 50%, passing said stock at a consistency in this range under pressure between opposed, relatively moving surfaces exerting a combing action on said stock, and the combing action continued until the rejects on a 0.012 inch cut screen are between 2% and 6%, a minimum clearance of at least 0.060 inch between opposed moving surfaces acting on said stock being maintained throughout said operations, the extent of cooking of the chips, the consistency of the stock subjected to the combing action and the combing action being so correlated as to produce a pulp having, after removal of shives and after bleaching to a brightness of at least 70 freeness of at least 200 cc. as measured after ball-milling for 100 minutes, and removing the shives from said stock.

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