

1

3,192,102

PULPING PROCESS

William J. Nolan, 1029 NE. 23rd Blvd.,
Gainesville, Fla.

No Drawing. Filed Aug. 15, 1962, Ser. No. 216,969
The portion of the term of the patent subsequent to
Sept. 15, 1976, has been disclaimed
19 Claims. (Cl. 162—24)

This application is a continuation-in-part of my application Serial No. 852,978, filed November 16, 1959, which in turn is a continuation-in-part of my application Serial No. 578,378, filed April 16, 1956, both now abandoned.

This invention relates to a process of treating cellulose fiber-bearing materials and, more particularly, relates to an improved process of removing the non-cellulosic material therefrom by the use of a digestion process for the manufacture of paper, cellulose for synthetic fibers, and the like.

It is a particular object of this invention to provide a method for producing papermaking pulps from wood or other cellulosic materials by a rapid continuous process, in which from about half to nearly all of the lignin is removed.

A further object is the production of cellulosic pulps having a high alpha cellulose content and a low lignin and pentosan content, which is useful for the manufacture of rayon, cellophane and like products.

Another object of the invention is the modification of existing so-called batch processes so that reaction time may be shortened, resulting in increased yield and improved quality of the resultant pulp.

A further object of the invention is the provision of such a process that is readily adaptable for the processing of various types of lignocellulose materials and wherein effective control is obtainable as the yield and composition of the resultant pulp.

In the past it has been common practice in the pulping industry to allow extended periods of time (1.0–2.5 hrs. in alkaline pulping, 5.0–15.0 hours in acid sulphite pulping) for the cellulosic raw material and the reacting liquors to reach the maximum, or cooking, temperature and pressure. This practice has been followed because of the generally accepted but mistaken belief that it is necessary for the reacting chemical solutions to completely penetrate the wood chips, or other cellulosic material, before the temperature becomes high enough for the delignification reaction to take place. It was erroneously believed that this slow penetration period was necessary to prevent degradation and solution of the cellulose fibers while lignin was being removed.

I have found, through very extensive experimentation, that penetration of cooking liquor into wood chips or other cellulosic material does not occur before the pulping reactions take place. Rather, the reactions themselves penetrate the material, delignifying the cellulose fibers as the reactions move toward the centers of the chips. This penetrating reaction, or moving reaction interface, opens up tiny passages around the fibers, permitting diffusion of fresh chemical toward the reacting interface and diffusion of reaction products outward to the main body of cooking liquor. These diffusional operations are not movements of a liquid medium but, rather, are movements of ions and molecules within a liquid medium caused by differences in concentration gradient.

As this moving reaction interface moves toward the center of the wood chip, a widening reaction zone develops, bounded on one end by the outer dimensions of the original chip, at the other end by the moving reaction interface. There is a lignin gradient across this reaction zone. At the interface end, the lignin content of the chip

2

is, of course, that of the original wood. At the outer end of this zone the lignin content of the material is much lower, being determined by the time of contact, temperature and chemical concentration.

This moving reaction interface theory is the basis for my invention. I have discovered that wood chips can be specially tailored, dimension-wise, to most efficiently meet the conditions set up by this moving interface. This so-called tailoring consists of, first, presenting the maximum possible wood surface to the initial reacting interface, where liquor comes in contact with the unreacted chip. Second, the chip is so designed that the distance which this reacting interface must travel to reach the center of the chip is reduced to a minimum.

Obviously, from a purely theoretical point of view, the most efficiently tailored chip would consist of a chip made of only one whole fiber. This is impossible of accomplishment without damaging the cellulose fibers because of the very strong bond between fibers, set up by the cementing lignin. Such attempts to reduce the wood to its individual fibers, as described in Asplund Patent No. 2,388,592, Offermanns Patent No. 2,164,040, Mason Patent No. 1,872,996, Walter Patent No. 2,454,532, Olsen Patent No. 1,979,341 and Australian Patent No. 12,149 (Asplund), cut and tear a high percentage of the cellulose fibers, resulting in reduced strength of the purified cellulose.

My invention comprises altering the chip dimensions by taking advantage of the physical weakness of the chip caused by the grain of the wood, then adjusting the pulping conditions to fit the new chip dimensions to produce a pulp of maximum yield and quality. A comparatively small force is required to break a chip if the break takes place in the grain direction. This force is variable, being at a maximum with dry wood, decreasing as the chip moisture increases and reaching a minimum when the lignin, the cementing material, is softened by application of heat. Since the cellulose fibers lie in the grain direction, none of these fibers are torn by the break. Much greater force is required to cause a break across the grain and such a break will tear a high percentage of the fibers located at or near the line of breakage.

In my invention I carry out this breaking or shredding of chips in the grain direction to as small a cross-section, across the grain, as possible. However, if cross-section is reduced excessively, the chip fragment becomes so weak, physically, that cross-grain breakage takes place and mechanical fiber damage occurs. The aim of my invention is to carry out this breaking or splitting of the chips along the grain, maintaining the same length of the split fragments as was present in the original whole chips which are ordinarily at least about 5/8 inch in length.

I have found that this shredding along the grain should be so adjusted that as much as possible of the shredded product will pass, end-wise, through a Tyler Standard 3 mesh screen and be retained on an 8 mesh screen. This indicates that the optimum range of cross-section dimension lies between 6.7 and 2.3 mm. Material slightly smaller in cross-section, passing 8 mesh but retained on 10 mesh (between 2.3 and 1.65 mm.) will suffer negligible cross-grain breakage and will cook to strong pulp. About 10–20% loss in tear strength has been found for the fraction between 10 and 16 mesh (1.65 to 0.99 mm.). Shredded material below 0.99 mm. in cross-section suffers severe loss in tear strength when converted to pulp.

At the other extreme of size range, material larger in cross-section than 6.7 mm. will, of course, suffer no mechanical damage. However, with these larger cross-sections, the path which the reaction must travel is so long that the smaller size ranges will be severely overcooked and suffer excessive chemical damage while the larger

cross-sections are being cooked. In addition, in high speed, continuous pulping, these larger cross-sections will result in excessive degradation and even solution of the outer cellulose fibers while the fibers near the chip centers are still being delignified. It can, therefore, be seen that both oversize and undersize should be kept at a minimum for efficient cooking. I have found that hammer mills, attrition mills, such as that disclosed in Patent No. 2,716,926, or other devices which will provide sufficient impact to split the chips along the grain can be used to carry out this shredding operation. When hammer mills are used, the size of the openings in the discharge screen through which the product falls is critical. Too small an opening increases fines, while too large an opening will produce insufficient splitting. I have used 1/2 inch expanded metal successfully for such a discharge screen in hammer milling. In attrition mill, toothed rather than bar type plates should be used. In this type mill, the clearance between plates and feed rate of chips are the controlling features. For any specific disc speed and chip feed rate, there is one specific clearance which will produce the optimum size range of chip cross-section. Clearances larger than this value will result in an excessive percentage of oversize, while smaller clearance results in excessive fines and cross-grain breakage. Properly operated, either hammer mills or attrition mills should perform the shredding operation for an energy expenditure of less than 0.5 H.P. days per O.D. ton of wood.

This shredding operation, which greatly increases wood surface and decreases the distance from the surface to the chip center, is essential to high speed, continuous pulping, which invariably involves substantially constant temperature and elimination of the warm-up period. I have found that it is also definitely beneficial in the slower, batch pulping where a warm-up period is used.

This application of reduction of chip cross-section without decrease in chip length to the commonly practical batch pulping can be illustrated by the following example. A sample of chips was taken from a commercial kraft mill chipper whose knives were dull and, as a consequence, 33.5% of the chips resulting were large enough to be retained on a screen with 3/4 in. square openings. Another sample was taken when the knives of the same chipper had been sharpened. In this chip sample, only 6.9% of the chips were retained on the 3/4 in. screen. Some of these latter chips were shredded by my process, resulting in a product, 90% of which had chip cross-sections varying between 1.65 and 6.65 mm. but whose length in the grain direction was the same as the original chips. Each of these samples was cooked by the kraft process, using identical conditions, including time. The yields of screened pulp amounted to 40.0% for the chips from dull knives, 45% for the chips from sharp knives and 48.6% from the shredded chips. The screened yield from the shredded chips would have been even higher if a shorter cooking time had been used but could not be improved for the full-size chips. This example shows how much damage can be caused, through the dissolving of cellulose fibers, by too wide a range of chip cross-sections in the same digester.

This principle of chip shredding to achieve maximum surface and minimum cross-section was first disclosed in my U.S. Patent No. 2,904,460, issued September 15, 1959. In this patent I disclosed a method for reducing the cross-section, across the grain, of dry chips which had been modified to avoid cross-grain breakage. In preliminary experiments I had found that the dry chips, untreated, were hard and brittle, offering considerable resistance to breaking along the grain. At the same time that the resistance to breaking along the grain was at a maximum, the resistance to breaking across the grain was at a minimum because of this brittleness. As a result of this brittleness, a great deal of fiber damage was done when shredding was attempted. As an example, slash pine chips containing 10% moisture were shredded in an attrition

mill, using a plate clearance of 0.445 in. The shredded product was separated into its various cross-sectional sizes by screening on Tyler Standard screens, using a Rotap sifter for mechanical action. The screen analysis of the product was as follows:

Screen mesh.....	3	-3 +4	-4 +8	-8 +10	-10 +16	-16
Percent on screen..	0.4	5.2	42.5	21.2	19.4	11.3

The material smaller than 10 mesh, 30.7% of the total product, had suffered severe fiber damage. A part of the material between 10 and 16 mesh was broken into pieces very short in the grain direction. All of the -16 mesh fraction was either dust or very short, thin fragments.

However, when I steamed these dry, brittle chips for very short periods of time in the range of 150-170 p.s.i.g., the lignin cementing the fibers together became soft, resulting in very flexible chips which would separate easily along the grain. The shredded fragments were so flexible that they could be bent almost double before breaking. This flexible characteristic was retained as the chips cooled to room temperature, as long as they were not allowed to become dry.

Upon shredding these steamed chips in the same mill as just described for the dry chips, using the same clearance of 0.445 in., the following screen analysis of the product resulted:

Screen mesh.....	3	-3 +4	-4 +8	-8 +10	-10 +16	-16
Percent on screen..	7.5	18.7	50.3	11.9	7.5	4.1

Upon close examination of the various screen fractions it was found that this analysis did not give the true size distribution of cross-sectional dimensions. The extreme flexibility of the fragments had left them entangled to such an extent that they interfered with each other, preventing passage through the proper screen. For example, hand sorting of the fractions disclosed that, of the material held on 3 mesh, only 12.5% was actually large enough in cross-section that it would not pass 6 mesh; 25% would go through 6 mesh but not through 8 mesh; 25.9% would pass through 8 mesh but not through 10 mesh; 36.6% would pass through 10 mesh. It can be seen, therefore, that screen analysis cannot provide a true picture of cross-sectional size when the chips are softened by presteaming before shredding.

The method used in screening shredded chips to separate them into their various cross-sectional dimensions is quite critical. The material must pass endwise through the screen if the screen is to be used as a measure of cross-section rather than length. Therefore, a Rotap sifter, or some similar device, must be used which will provide a bouncing as well as a shaking action so that the chips will pass endwise through the screen. The usual reciprocating sifter is not satisfactory, since it separates chips primarily by length along the grain.

Subsequent to my disclosure in U.S. Patent 2,904,460, I have discovered that non-pretreated chips containing from about 20% to 50% by weight of moisture can be shredded reasonably well if proper precautions are taken. Chips obtained from logs will have an average moisture content within the above specified range so long as they are not subjected to special drying or presteaming procedures. Such chips are hereinafter referred to as "green" chips. The amount of surface opened up by the shredding operation is not as great as when the chips are steamed before shredding because the chips are not nearly as soft and flexible. Consequently, the ends of the shredded fragments do not broom out to expose greater surface, as do the steamed chips. Furthermore, it is not possible to obtain the extremely slender sections, as long as the orig-

5

inal chips, always found in the shredded mixture from steamed chips.

However, the shredding of green chips, if it can be done without excessive mechanical damage, offers two great advantages over the presteamed shredding. First, the presteaming operation is costly, probably almost as expensive as the cooking itself because the same type pressure vessel must be used. In this presteaming, part of the pentosan in the wood is reacted and removed by the steaming operation. Second, the bulky character of the presteamed, shredded product, mentioned previously as a characteristic which prevents accurate screen analysis, will not permit the loading of nearly as much shredded chips in the digester as when conventional chips are used, causing serious curtailment in production. Green chips shredded without presteaming, on the other hand, have the same packing characteristics as conventional chips.

It is true that, in the shredding of green chips without presteaming, the wood is much more subject to mechanical damage by cross-grain breakage than is the presteamed wood. If the shredding is carried out to the same degree, that is, to the point where practically all the shredded product will pass endwise through a 3 mesh screen, much more cross-grain breakage will occur with the green chips. Furthermore, the amount of this damage from shredding will increase as the chips dry out. It has been pointed out earlier that the chips become more brittle as they become dry. The following example shows how much more damage is done as chips become dry. The untreated chips were shredded, as in previous examples, in the attrition mill with a plate clearance of 0.445 in.

Chip moisture (percent)	Percentage held on each screen					
	3 mesh	-3 +4 mesh	-4 +8 mesh	-8 +10 mesh	-10 +16 mesh	-16 mesh
10-----	0.4	5.2	42.5	21.2	19.4	11.3
45-----	0.0	9.7	45.5	18.0	16.3	10.4

Considering the percentage of material passing 10 mesh as a measure of fiber damage, 26.7% of the wood containing 45% moisture was damaged, either slightly or seriously, while the wood containing 10% moisture was damaged to the extent of 30.7%. In addition, an examination of the acceptably shredded fraction, that material passing 3 mesh and retained on 10 mesh, showed that the dry (10% moisture) material had also suffered some damage. The long, slender pieces of the dry shreds showed damage along the surface parallel to the grain. This surface was rough, with indentations where tiny fragments had broken away, caused by impact on the brittle chips. Thus, even the acceptably shredded fraction of the dry chips suffered more fiber damage than the corresponding fraction of the moist chips.

A comparison of these data for the shredding of untreated chips with the similar data listed earlier for presteamed chips at the same attrition mill clearance of 0.445 in. shows that the fraction smaller than 10 mesh is extremely low for the presteamed chips, 11.6%. As stated earlier, even this 11.6% of material of very small cross-section has suffered very little cross-grain breakage because of its great flexibility.

It thus becomes apparent that untreated green chips, regardless of the amount of natural moisture they contain, cannot be successfully shredded to the extent that all of the shredded product will pass 3 mesh. So much cross-grain breakage occurs that more mechanical damage is done than the chemical damage which is avoided in the digester.

However, I have found that the property of the shredded untreated green chips to screen easily into screen fractions having sharply defined cross-sectional dimensions can be used to create a product in which most of the material will pass endwise through a 3 mesh screen but will not contain an excessive fraction smaller than 10 mesh. If

6

the clearance of the attrition mill is increased, the shredded particles increase in cross-section and the fraction which is smaller in cross-section than 10 mesh becomes smaller. The following tabulation shows how these cross-sectional size ranges change with attrition mill clearance, using green chips containing 45% moisture.

Plate clearance (in.)	Percentage held on each screen (based on original wood)					
	3 mesh	-3 +4 mesh	-4 +8 mesh	-8 +10 mesh	-10 +16 mesh	-16 mesh
0.445-----	0.0	9.7	45.5	18.0	16.3	10.4
0.775-----	22.2	28.3	36.0	6.4	4.5	2.7
0.971-----	35.6	27.4	27.8	5.3	2.8	1.1

When the shredded products are passed over a 3 mesh screen, using a vibrating motion which will up-end the chips on the screen so that they pass endwise through the openings whereby the oversized particles are removed, the analyses of the screened products become:

Plate clearance (in.)	Percentage held of each screen (based only on particles -3 mesh size or smaller)					
	+3 mesh	-3 +4 mesh	-4 +8 mesh	-8 +10 mesh	-10 +16 mesh	-16 mesh
0.445-----	0.0	9.2	45.5	18.0	16.3	10.4
0.775-----	0.0	36.3	46.2	8.2	5.8	3.6
0.971-----	0.0	42.6	43.2	8.2	4.3	1.7

The oversize material, amounting to 35.6% of the original wood in the case of 0.971 plate clearance, can be returned to the attrition mill, mixed with fresh chips for reshredding. This can be done economically since the cost of shredding is extremely low.

It can thus be seen that a wide range of screen analyses can be attained in the shredded product, depending on how much fine, mechanically damaged material can be tolerated in the product. This process requires the installation of adequate screening equipment in addition to the shredding equipment. However, the total cost of operations will be much less than steaming the chips before shredding and a good control of cross-sectional size range can be obtained.

In some instances, especially in batch pulping, the screening after shredding and recycling of oversize can be eliminated. The shredding operation alone will produce processed chips considerably more uniform than the chips coming directly from the chipper and an improvement in yield and quality will result. However, if maximum improvement is to be realized, screening-out and recycling of oversize should be practiced.

The fundamental purpose of this chip shredding is to tailor the shape of the wood chips to best fit the kinetic laws of pulping which I have found to be true. As was pointed out earlier the ideal cross-sectional dimensions of the wood for most efficient cooking by the alkaline, neutral or acid processes should consist of particles only about one fiber thick. Such pulping conditions as liquor concentration and temperature could be made quite severe without damaging the fibers because the time required to delignify a single fiber would be very short. Since the individual fibers could be removed from the cooking zone immediately after they have lost their protective covering of lignin, degradation and dissolution of cellulose could almost be eliminated.

However, the information just presented showed that about the best cross-sectional reduction without serious mechanical damage that can be attained on chips that have not been presteamed will lie in the size range between 1.65 and 6.7 mm. It is obvious that reduction to this size range will not result in delignification without at least some degradation and dissolution of cellulose. As long as the chip cross-sections are several fibers thick, the outer fibers will be delignified and be vulnerable to degradation while the inner fibers are being delignified. What I have

discovered is that tailoring the chips to this cross-section range of 1.65 to 6.7 mm., then adjusting such cooking conditions as liquor concentration, temperature and time to best fit this attainable range of chip cross sections, will result in improved yield and quality in batch pulping; will permit high speed, continuous pulping to produce pulps of good yield and quality, not attainable if this tailoring of chip cross-sections is not carried out.

My invention, therefore, relates to a process which consists of subdividing green chips of fiber-bearing materials having a moisture content of from about 20% to about 50% to produce a shredded product consisting of three fractions, the first (1) fraction comprising a substantial proportion, usually at least 50% by weight or more of the total shredded product and the particles of which have at least one transverse (cross-grain) dimension of at least about 1.65 mm. and no transverse dimension greater than about 6.7 mm. the second (2) fraction comprising not more than about 5% by weight of the total shredded product and the particles of which have no transverse dimension in excess of about 1.65 mm. and the third (3) fraction comprising at least 25% by weight of the total shredded product and the particles of which have a transverse dimension in excess of about 6.7 mm., the lengthwise dimensions along the grain of the chips being substantially the same as the original chips. Stated differently the particles of the (1) fraction will pass endwise through a Tyler Standard 3 mesh screen and will be retained on a Tyler Standard 10 mesh screen, the (2) fraction will pass endwise through Tyler Standard 10 mesh screen and the (3) fraction will not pass endwise through a Tyler Standard 3 mesh screen. The shredded product preferably will then be screened to separate the particles whose transverse dimensions are in excess of 6.7 mm. However, if a lower quality product is desired, this latter screening step need not be performed. The term "shredded product" as used in the claims shall include either a product from which particles whose transverse dimensions are in excess of 6.7 mm. have not been removed or a product from which such particles have been removed. The shredded product is then digested by applying a digesting liquor of the alkaline, neutral sulfite or acid bisulfite type thereto and heating the shredded product and the digesting liquor to the digesting temperature as quickly as possible and holding the mixture at the digesting temperature for the period of time required to produce a pulp of the desired characteristics.

For soda, kraft and acid bisulphite digestion operations, the shredding of the chips and the subsequent digestion thereof under the conditions described hereinafter have been found to result in a higher screened yield of pulp with a shorter digestion time and the pulp has a higher degree of polymerization number, indicating better quality, than is possible with mill size chips, that is, chips passing through a screen having openings 1.0 x 2.0 inches in size. For neutral sulphite semichemical digestion operations, the use of shredded chips provides a more uniformly softened pulp which can be fibrated with less expense than pulp formed from mill size chips. Further, the pulp from shredded chips is much brighter.

Hardwoods and conifers can be simultaneously digested successfully in the same digester. The conifer chips should be shredded to relatively small cross sections while hardwood chips should be shredded to relatively larger cross sections. The degree of shredding will depend on the particular species of wood involved. The shredding is selected to compensate for the difference in the normal rate of pulping of the species involved.

Degree of polymerization is a measure of the number of cell obiose groups in the cellulose molecule and is calculated from viscosity measurements as prescribed in TAPPI Standard No. T-230. It is generally considered to be a measure of pulp quality, the higher the number the better the quality. In the following description it is abbreviated as D.P.

KRAFT OR SODA PROCESS

BATCH OPERATION

In kraft or soda batch digestion operations, according to the invention, the shredded chips, whose cross-grain dimensions are substantially within the range of between 1.65 and 6.7 mm., are digested with a liquor consisting essentially of sodium hydroxide alone or in combination with sodium sulphide. The concentration of the cooking liquor is from 20 to 55 grams per liter measured as Na_2O . The sulphidity ranges from 0 to 35%. The maximum temperature is between about 170 and 180° C. The contents of the digester are heated to maximum temperature in from 30 to 120 minutes and the contents of the digester are maintained at the maximum temperature for from 10 to 60 minutes.

The digestion operation is then terminated by blowing the digester. The screened yield of pulp from a digesting operation of the type above described will normally be between about 45% and about 52% by weight of the original wood.

A high yield digesting operation may be performed under the same conditions as described above except that the contents of the digester are maintained at the maximum temperature for a period of 0 to 45 minutes. The pulp after being discharged from the digester is then fibrated in an attrition mill or similar device. In this type of operation, the total yield will normally be between about 50% and about 65% by weight of the original wood.

Example 1

Shredded slash pine chips of -4 +8 mesh size in cross-grain direction were digested in a liquor whose starting concentration was 50 g.p.l. as Na_2O with a sulphidity of 25%. The time to raise the contents of the digester to maximum temperature was 60 minutes and the maximum temperature was 175° C. The liquor-to-wood ratio was 3.4:1. The time at maximum temperature was 35 minutes. The screened yield was 47.5% of original wood and the total yield was 47.6%. The percent lignin in the pulp was 8.0% and the D.P. of the pulp was 1718.

Mill-size chips were subjected to the same digestion conditions. The results were: screened yield 36.6%, total yield 51.9%, percent lignin in pulp 9.1 D.P. of pulp 1753.

A further series of digesting operations for both shredded and mill size chips was conducted under the same conditions except that the times at maximum temperature were varied from 5 to 65 minutes for mill-size chips and from 5 to 35 minutes for shredded chips. A maximum screened yield of 48.2% for shredded chips was achieved at 25 minutes at maximum temperature. The D.P. of this pulp was 1837. The maximum screened yield of the mill-size chips was 40% realized at 65 minutes at maximum temperature. The D.P. of this pulp was 1610. Thus, shredding increased screened yield, decreased cooking time, and improved the quality of the pulp.

CONTINUOUS OPERATION

In continuous pulping operations, chips and liquor are fed into one end of a pressure vessel by one of several methods such as by using high compression screws, compartmented feeder valves and the like. The mixture is conducted through the length of the pressure vessel which is held at a constant high pressure and temperature. The mixture of reacted materials is discharged at the other end of the vessel through any suitable type of pressure relieving device.

A continuous process for digesting green shredded chips by the kraft or soda processes to produce a paper making pulp, according to invention, includes continuously forwarding chips whose cross-grain dimensions are substantially within the range of between 1.65 and 6.7 mm. through a digester and contacting same with a cooking liquor consisting essentially of sodium hydroxide alone or in combination with sodium sulphide. The concentra-

tion of the cooking liquor is from 20 to 55 grams per liter measured as Na_2O . The concentration of the liquor may be allowed to fall during the digestion operation or it may be maintained substantially constant, such as by adding extra liquor to the digester. The sulphidity of the cooking liquor ranges from 0 to 35%. The contents of the digester are continuously maintained at a temperature within the range of 175° to 190° C. for a period of time ranging from 10 to 75 minutes, following which they are discharged therefrom.

The liquor-to-wood ratio may vary between about 3.0:1 and about 10.0:1. In general, the lower the liquor-to-wood ratio, the higher the concentration and the lower the digesting temperature and vice versa. Thus, if the liquor-to-wood ratio is 3.0:1, the concentration should be about 50 g.p.l. as Na_2O and the digesting temperature should be 175° to 178° C. If the liquor-to-wood ratio is 10.0:1, the concentration can be about 20 g.p.l., as Na_2O and the digesting temperature can be about 190° C. The screened yield of pulp from this digesting operation will normally be between 45% and 52% of the original wood.

A high yield continuous process for papermaking pulp involves the same steps as just described except that the shredded chips are maintained at the digesting temperature for a time period of from 5 to 50 minutes and after being discharged are mechanically fibrated in an attrition mill or similar device.

A continuous process for digesting shredded chips to produce a dissolving pulp containing less than 3% pentosan for making rayon, etc., involves contacting shredded chips of the size specified above with a kraft or soda cooking liquor having a concentration of 70 to 90 grams per liter measured as Na_2O and a sulphidity of from 0 to 35%. The chips are maintained at a constant temperature ranging from 162° to 178° C., and are retained in the digester for a time period of from 5 to 40 minutes. The screened yield of pulp will be in the range of 38% to 48% of the original wood.

The same kraft or soda cooking liquor may be used in two successive continuous digesting operations to produce from the first digesting operation a dissolving pulp and to produce from the second digesting operation a paper-making pulp. According to such a procedure, in the first digestion operation shredded green chips of the size specified above are digested with a kraft or soda cooking liquor whose initial concentration is 70-90 grams per liter measured as Na_2O and which has a sulphidity of from 0 to 35%. The cooking temperature is constant at between 162° and 178° C. and the cooking time is from 5 to 40 minutes. The liquor is expressed or drained from the pulp exiting from the first digestion operation and its concentration is then adjusted so that it contains from 20 to 55 grams per liter measured as Na_2O . Ordinarily, since the first digestion operation usually does not consume sufficient of the chemicals to reduce the concentration to this value, adjustment of the concentration is effected by dilution. However, it will be understood that if the liquor after the first digestion operation is below the desired concentration, additional chemicals may be added thereto to bring it to the desired concentration. The liquor, at a concentration of 20 to 55 grams per liter measured as Na_2O and a sulphidity of 0 to 35%, is then utilized to digest other shredded green chips of the size specified above in a second continuous digestion operation to produce a papermaking grade of pulp. The digestion temperature for the second digesting operation is constant at between 170° and 190° C. and the cooking time is 10 to 75 minutes.

Example II

Shredded slash pine chips of -4 +8 mesh size in cross-grain direction were continuously digested utilizing a liquor whose initial concentration was 35 g.p.l. as Na_2O with a sulphidity of 25%. The temperature was main-

tained constant at 185° C. The digesting time was 20 minutes. The results were: screened yield 45.8%, total yield 49.1%, percent lignin in pulp 10.0%, D.P. of pulp 1634.

5 Mill-size chips were subjected to identical digestion conditions. The results were: screened yield 18.2%, total yield 62.4%, percent lignin in pulp 11.5%, D.P. of pulp 1703.

A further series of digesting operations for both 10 shredded and mill-size chips was conducted under the same conditions except that the digesting times were varied from 10 to 45 minutes for mill-size chips and from 10 to 30 minutes for shredded chips. The maximum screened yield for shredded chips was 46.5% at 18 minutes cooking time and a D.P. of 1650. The maximum 15 screened yield for mill-size chips was about 35% at a cooking time of about 40 minutes and the D.P. for this pulp was 1450. Again, shredding the chips increased screened yield, decreased cooking time and improved the 20 quality of the pulp.

Example III

Shredded slash pine chips of -4 +8 mesh size were continuously digested while maintaining the concentration of the cooking liquor substantially constant. The 25 conditions were: concentration of liquor 20 g.p.l. as Na_2O ; sulphidity 25%; temperature 190° C.; time 28 minutes. The results were: screened yield 42.5%; total yield 43.3%; percent lignin in pulp 7.8%, D.P. of pulp 1493.

30 Mill-size chips were subjected to the same digestion conditions. The results were: screened yield 23.3%, total yield 58.3%; percent lignin in pulp 9.2%, D.P. of pulp 1614.

A further series of continuous, constant concentration, 35 digesting operations were carried out for shredded and mill-size chips under the same conditions except that the digestion time was varied from 15 to 90 minutes for mill-size chips and was varied from 12 to 35 minutes for shredded chips. For shredded chips, the maximum 40 screened yield was about 45%, at 20 minutes cooking time, and the pulp had a D.P. of about 1600. For mill-size chips the maximum screened yield was about 36%, at about 75 minutes cooking time and the pulp had a D.P. of about 1020.

ACID BISULPHITE PROCESS

In acid bisulphite digestion operations, the cooking chemical is a mixture of sulphurous acid and a bisulphite salt of sodium, ammonium, calcium, or magnesium. 50 Ammonia base was selected for the purpose of the following examples, instead of sodium, calcium or magnesium, because it is less corrosive and is less subject to decomposition at high temperature than the other salts. However, the invention includes within its scope any 55 of the above-mentioned bisulphite salts.

The nomenclature utilized in the following examples, namely, "total," "free" and "combined" SO_2 follows the accepted terms of the sulphite pulping literature. Combined SO_2 is defined as that amount of SO_2 combined 60 with the base ammonium as bisulphite but calculated as though it were ammonium sulphite. It is only half of the SO_2 which would be necessary to form ammonium bisulphite with all of the ammonia present. The free SO_2 is all of the SO_2 present as sulphurous acid plus half 65 of the SO_2 which is present as ammonium bisulphite. Total SO_2 is the sum of free and combined SO_2 .

BATCH OPERATION

In batch digesting operations according to the acid 70 bisulphite process, shredded chips, whose cross-grain dimensions are substantially within the range of between 1.65 and 6.7 mm., are digested with a liquor containing from 4.0% to 6.0% total SO_2 and 0.8% to 1.6% combined SO_2 (based on the weight of the liquor). The maximum digestion temperature is between about 148°

and 165° C. The contents of the digester are heated to maximum temperature in from 30 to 120 minutes and the contents of the digester are maintained at the maximum temperature for from 30 to 150 minutes. The screened yield of pulp from such a digesting operation will normally be between 45% and 52% of the original wood.

A high yield digesting operation may be performed under the same conditions as described above except that the contents of the digester are maintained at the maximum temperature for a period of from 10 to 100 minutes. The pulp after being discharged from the digester is then fibrated in an attrition mill or similar device. In this type of operation, the total yield will normally be between about 50% and about 70% of the original wood.

Example IV

Shredded spruce chips of -4 +8 mesh size in the cross-grain direction were digested in a liquor whose concentration was 5.2% total SO₂ and 1.2% combined SO₂. The maximum temperature was 148° C. The time to reach maximum temperature was 30 minutes and the time at maximum temperature was 120 minutes. The liquor-to-wood ratio was 7 liters liquor to 1000 g. of O.D. wood. The screened yield was 50.6% of the original wood and the total yield was 52.4%. The percent lignin in the pulp was 8.2% and the D.P. of the pulp was 1899.

Mill-size chips were subjected to the same digesting conditions except that the time at maximum temperature was 135 minutes. The results were: screened yield 39.4%, total yield 52.4%, percent lignin in pulp 5.7% and D.P. of pulp 1850.

A further series of digesting operations for both shredded and mill-size chips was conducted under the same conditions except that the digesting times were varied from 0 to 120 minutes for shredded chips and from 0 to 180 minutes for mill-size chips. The maximum screened yield for shredded chips was about 50.6% at 120 minutes cooking time and the pulp had a D.P. of 1899. The maximum screened yield for mill-size chips was about 42% at 180 minutes cooking time and the pulp had a D.P. of 1659.

Two further series of digesting operations were performed for both shredded and mill-size chips in which the time to raise the material to the cooking temperature for both types of chips was, respectively, 360 minutes and 540 minutes. In each case, it was found that shredded chips achieved a higher screened yield more rapidly and the resultant pulp had a higher D.P. than did the mill-size chips.

CONTINUOUS OPERATION

A continuous process for digesting shredded chips by the acid bisulphite process, according to the invention, includes continuously forwarding chips whose cross-grain dimensions are substantially within the range of 1.65 and 6.7 mm. through a digester and contacting same with a cooking liquor whose concentration is from 4.0% to .60% total SO₂ and 0.8% to 1.6% combined SO₂. The digesting temperature is constant within the range of between 148° and 165° C. The digesting time is between 45 and 120 minutes. The screened yield of pulp from this digestion operation will normally be between 42% and 50% of the original wood.

It is beneficial to preimpregnate the shredded chips with a dilute bisulphite salt solution with no excess sulphurous acid. The concentration of this preimpregnation solution is between 0.8% and 1.6% combined SO₂ and 1.6% to 3.2% total SO₂. The shredded chips are treated by placing same in the solution while it is boiling for a short period of time, such as 10 minutes, cooling rapidly to about 50° to 65° C. and then draining the excess liquor. Vacuum impregnation and soaking of the chips for several hours are also suitable. The pretreatment of the chips with the bisulphite salt will result

in a substantial increase in the screened yield of the pulp and also a slightly increased D.P.

A high yield continuous process involves the same steps as just described except that the shredded chips are maintained at the digesting temperature for a time period of from 20 to 100 minutes and, after being discharged, are mechanically fibrated in an attrition mill or a similar device.

Example V

Shredded spruce chips of -4 +8 mesh size in cross-grain direction were digested in a liquor whose starting concentration was 4.4% total SO₂ and 1.2% combined SO₂. The temperature was maintained constant at 148° C. The digesting time was 120 minutes. The results were: Screened yield 44.3%, total yield 51.2%, percent lignin in pulp 6.2%; D.P. of the pulp was 1682.

Example VI

Shredded spruce chips of -4 +8 mesh size were pretreated by boiling same for 10 minutes and then cooling same in a bisulphite liquor whose concentration was 2.3% total SO₂ and 1.2% combined SO₂. The chips were then subjected to the same digesting conditions as described in Example V except that the digesting liquor has 4.6% total SO₂. The results were: screened yield 50%; total yield 50.9%; percent lignin in pulp 7.5%; D.P. of the pulp was 1740.

BISULPHITE PROCESS

In this variation of the acid bisulphite process, free sulphurous acid is eliminated, the cooking chemical being only the bisulphite salt of ammonia, sodium, calcium or magnesium. The pulping reaction is slower than for acid bisulphite pulping but pentosan in the pulp is conserved because acid hydrolysis is reduced to a minimum by the pH of the liquor, usually in the range of 5.0 to 6.0.

A continuous process for digesting shredded chips by the bisulphite process, according to the invention, includes continuously forwarding chips whose cross-grain dimensions are substantially within the range of 1.65 and 6.7 mm. through a digester and contacting same with a cooking liquor whose concentration is from 3.0% to 8.0% total SO₂, and 1.5% to 4.0% combined SO₂. The digesting temperature is constant within the range of between 148° and 180° C. The digesting time is between 45 and 180 minutes. The total yield of pulp from this digestion operation will normally be between 48% and 72% of the original wood. At the higher yields a fibration treatment of the cooked chips is necessary to reduce the soft chip fragments to fibers.

It is beneficial to preimpregnate the shredded chips with a bisulphite salt solution, not necessarily as high in concentration as that of the cooking liquor itself. The concentration of this preimpregnating solution may lie between 1.6% and 6.0% total SO₂, 0.8% and 3.0% combined SO₂. The shredded chips are treated by placing same in the solution while it is boiling for a short period of time such as 10 minutes, cooling rapidly to about 50° to 65° C. and then draining the excess liquor. Vacuum impregnation and impregnation by soaking of the chips for several hours is also suitable. The pretreatment of the chips with the bisulphite salt will result in a substantial decrease in cooking time and, at the higher yields, more uniformly soften chips.

NEUTRAL SULPHITE SEMI-CHEMICAL PROCESS

BATCH OPERATION

In batch digestion operations according to the neutral sulphite chemical process, the shredded chips whose cross-grain dimensions are substantially between the range of 1.65 and 6.7 mm. are digested with a liquor consisting essentially of a mixture containing sodium sulphite and sodium carbonate. The concentration of the cooking liquor is from 20 to 75 grams per liter measured as Na₂O,

of which 60% to 80% is present as sodium sulphite and the remainder is sodium carbonate. The maximum digesting temperature is between about 165° and 178° C. The contents of the digester are brought to maximum temperature in from 30 to 90 minutes and are maintained at the maximum temperature for a period ranging from 100 to 240 minutes. The screened yield of a pulp from such a digesting operation will normally range from 62% to 78% of the original wood. The pulp, after being discharged from the digester, is then fibrated in an attrition mill or similar device.

A continuous process for digesting shredded chips by the neutral sulphite semi-chemical process includes continuously forwarding the chips whose cross-grain dimensions are substantially within the range of 1.65 to 6.7 mm., through a digester and contacting same with a cooking liquor consisting essentially of sodium sulphite and sodium carbonate. The concentration of the cooking liquor is from 20 to 75 grams Na_2O per liter of which from 60% to 80% is present as sodium sulphite and the remainder as sodium carbonate. The contents of the digester are continuously maintained at a temperature of between 185° and 200° C. for a period of 20 to 90 minutes following which the pulp is discharged therefrom. The pulp is then fibrated by passing same through an attrition mill or similar device. The total yield of the pulp normally ranges from between 62% and 78% of the original wood.

A pretreatment of the shredded chips with cooking liquor before same are fed to the digester will bring about a reduction in the cooking time.

Example VII

Shredded eucalyptus chips of -4 +8 mesh size in cross-grain direction were continuously digested in a liquor whose concentration was 12.5% (Na_2O), 4 mols Na_2SO_3 per mol Na_2CO_3 . The liquor-to-wood ratio was 7:1. At a constant temperature of 193° C. and a cooking time of 45 minutes, the total yield was 71.3% and G.E. brightness of the pulp was 37. Mill-size chips cooked under identical conditions resulted in the same yield but with a G.E. brightness of 20.6. The shredded chips, after cooking, were soft throughout while the mill-size chips had hard, dark centers.

Shredded eucalyptus chips were cooked under the same conditions as in the preceding example except that they were pretreated with cooking liquor before being cooked, the pretreating consisting in submerging the chips in boiling liquor for 10 minutes, cooling the chips and the liquor to 140° F. while the chips are submerged and then draining the chips. The cooked chips, after a cooking time of 45 minutes, had a total yield of 67.8% and a G.E. brightness of 37.5. Mill-size chips, treated identically, had a total yield of 69.7% and a G.E. brightness of 26.7. The cooked, pretreated chips were softer than the cooked mill-size chips.

While a variety of specific examples have been given, it will be understood that the invention is not limited to the conditions set forth therein but includes all conditions falling within the scope of the appended claims.

What is claimed is:

1. A process for converting chips of a cellulose fiber-bearing material, such as wood, into a pulp product, which consists of the steps:

subdividing green chips of fiber-bearing materials having a moisture content of from about 20% to about 50% by shredding the chips along the grain to produce a shredded product consisting of particles of which (1) a substantial proportion have at least one transverse dimension in excess of about 1.65 mm. and no transverse dimension greater than about 6.7 mm., (2) not more than about 5% have no transverse dimensions in excess of about 1.65 mm., and (3) at least 25% have at least one transverse dimension

in excess of about 6.7 mm., the lengthwise dimensions of the chips being substantially the same as the original chips;

digesting the shredded product by applying thereto a digesting liquor and heating the particles and the digesting liquor to the digesting temperature as quickly as possible and holding the mixture at the digesting temperature for the period of time required to produce a pulp of the desired characteristics.

2. A process according to claim 1, in which the shredded product is screened, prior to application thereto of the digestion liquor, to remove the particles whose transverse dimensions are in excess of about 6.7 mm. and recycling these particles through the subdivision step.

3. A process for digesting a cellulose fiber-bearing material, such as wood, with digesting chemicals to produce a pulp product, including the steps:

subdividing green chips of fiber-bearing materials having a moisture content of from about 20% to about 50% by shredding the chips along the grain to produce a shredded product consisting of particles of which (1) a substantial proportion have at least one transverse dimension in excess of about 1.65 mm. and no transverse dimension greater than about 6.7 mm., (2) not more than about 5% have no transverse dimensions in excess of about 1.65 mm., and (3) at least 25% have at least one transverse dimension in excess of about 6.7 mm., the lengthwise dimensions of the chips being substantially the same as the original chips;

digesting the shredded product by applying thereto a digesting liquor, the digesting conditions being selected from one of the following sets of conditions:

(a) digesting chemicals—sodium hydroxide and sodium sulfide

concentration of digesting chemicals—20–55 grams Na_2O per liter
sulphidity 0–35%
time to maximum temperature—less than about 120 minutes
time at maximum temperature—less than about 75 minutes
maximum temperature—170–190° C.

(b) digesting chemicals—sodium hydroxide and sodium sulfide

concentration of digesting chemicals—70–90 grams Na_2O per liter
sulphidity 0–35%
digesting chemicals applied at maximum temperature of between about 162–178° C.
time at maximum temperature—5–40 minutes

(c) digesting chemicals—acid bisulphite solution
concentration—4.0–6.0% total SO_2 , 8–1.6% combined SO_2

time to maximum temperature—less than about 120 minutes
time at maximum temperature—less than about 120 minutes
maximum temperature—148–178° C.

(d) digesting chemicals—neutral sulphite solution
concentration—20–75 grams Na_2O per liter, 60–80% sodium sulphite, balance sodium carbonate

time to maximum temperature—less than about 90 minutes
time at maximum temperature—less than about 240 minutes
maximum temperature—165–200° C.

whereby the particles are rapidly digested.

4. A process for digesting a cellulose fiber-bearing material, such as wood, with a cooking liquor to produce a pulp for paper-making purposes, including the steps:

subdividing green chips of fiber-bearing materials having a moisture content of from about 20% to about 50% by shredding the chips along the grain to

produce a shredded product consisting of particles of which (1) a substantial proportion have at least one transverse dimension in excess of about 1.65 mm. and no transverse dimension greater than about 6.7 mm., (2) not more than about 5% have no transverse dimensions in excess of about 1.65 mm., and (3) at least 25% have at least one transverse dimension in excess of about 6.7 mm., the lengthwise dimension of the chips being substantially the same as the original chips;

cooking the shredded product in a liquor consisting essentially of sodium hydroxide alone or in combination with sodium sulphide, the liquor containing from 20 to 55 grams as Na_2O per liter and having a sulphidity ranging from 0 to 35%, allowing from 30 to 120 minutes for particles and liquor to reach a maximum temperature in a range between 170 and 180° C., then cooking at this constant temperature for 10 to 60 minutes.

5. A process for digesting cellulose fiber-bearing material, such as wood chips, with a cooking liquor to produce a pulp for paper-making purposes, including the steps:

subdividing green chips of fiber-bearing materials having a moisture content of from about 20% to about 50% by shredding the chips along the grain to produce a shredded product consisting of particles of which (1) a substantial proportion have at least one transverse dimension in excess of about 1.65 mm. and no transverse dimension greater than about 6.7 mm., (2) not more than about 5% have no transverse dimensions in excess of about 1.65 mm., and (3) at least 25% have at least one transverse dimension in excess of about 6.7 mm., the lengthwise dimensions of the chips being substantially the same as the original chips;

cooking the shredded product in a liquor consisting essentially of sodium hydroxide alone or in combination with sodium sulphide, the liquor containing from 20 to 55 grams as Na_2O per liter and having a sulphidity ranging from 0 to 35%, allowing from 30 to 120 minutes for chips and liquor to reach a maximum temperature in a range between 170° and 180° C., then cooking at this constant temperature for 0 to 45 minutes and then mechanically defibering the partially cooked chips to pulp.

6. A process for digesting a cellulose fiber-bearing material, such as wood, with a cooking liquor to produce a pulp for papermaking purposes, including the steps:

subdividing green chips of fiber-bearing materials having a moisture content of from about 20% to about 50% by shredding the chips along the grain to produce a shredded product consisting of particles of which (1) a substantial proportion have at least one transverse dimension in excess of about 1.65 mm. and no transverse dimension greater than about 6.7 mm., (2) not more than about 5% have no transverse dimensions in excess of about 1.65 mm., and (3) at least 25% have at least one transverse dimension in excess of about 6.7 mm., the lengthwise dimensions of the chips being substantially the same as the original chips;

continuously cooking the shredded product in a liquor consisting essentially of sodium hydroxide alone or in combination with sodium sulphide at a constant temperature, the liquor containing from 20 to 55 grams as Na_2O per liter and having a sulphidity ranging from 0-35%, the chips and liquor being maintained at a constant temperature ranging from 175° to 190° C. for a period of from 10 to 75 minutes.

7. A process for digesting cellulose fiber-bearing material, such as wood, with a cooking liquor to produce a pulp containing less than 3% pentosan, to be used for

the manufacture of rayon, cellulose films and the like, including the steps:

subdividing green chips of fiber-bearing materials having a moisture content of from about 20% to about 50% by shredding the chips along the grain to produce a shredded product consisting of particles of which (1) a substantial proportion have at least one transverse dimension in excess of about 1.65 mm. and no transverse dimension greater than about 6.7 mm., (2) not more than about 5% have no transverse dimensions in excess of about 1.65 mm., and (3) at least 25% have at least one transverse dimension in excess of about 6.7 mm., the lengthwise dimensions of the chips being substantially the same as the original chips;

continuously cooking the shredded product in a liquor consisting essentially of sodium hydroxide alone or in combination with sodium sulphide at a constant temperature, the liquor containing from 70 to 90 grams Na_2O per liter and having a sulphidity ranging from 0 to 35%, the particles and liquor being maintained at a constant temperature ranging from 162° to 178° C. for a period of from 5 to 40 minutes.

8. A process for digesting cellulose fiber-bearing material, such as wood chips, with a cooking liquor to produce a pulp for papermaking purposes, including the steps:

subdividing green chips of fiber-bearing materials having a moisture content of from about 20% to about 50% by shredding the chips along the grain to produce a shredded product consisting of particles of which (1) a substantial proportion have at least one transverse dimension in excess of about 1.65 mm. and no transverse dimension greater than about 6.7 mm., (2) not more than about 5% have no transverse dimensions in excess of about 1.65 mm., and (3) at least 25% have at least one transverse dimension in excess of about 6.7 mm., the lengthwise dimensions of the chips being substantially the same as the original chips;

continuously cooking the shredded product in a liquor consisting essentially of sodium hydroxide alone or in combination with sodium sulphide at a constant temperature, the liquor containing from 20 to 55 grams Na_2O per liter and having a sulphidity ranging from 0 to 35%, the particles and liquor being maintained at a constant temperature ranging from 175° to 190° C. for a period of from 5 to 50 minutes and then mechanically fibrating the partially cooked particles to fiber.

9. A process for utilizing the same liquor for digesting cellulose fiber-bearing material, such as wood chips, to produce two grades of pulp, the first containing less than 3% pentosan to be used for the manufacture of rayon, cellulose films and the like, the other to be used for paper-making purposes, including the steps:

subdividing green chips of fiber-bearing materials having a moisture content of from about 20% to 50% by shredding the chips along the grain to produce a shredded product consisting of particles of which (1) a substantial proportion have at least one transverse dimension in excess of about 1.65 mm. and no transverse dimension greater than about 6.7 mm., (2) not more than about 5% have no transverse dimensions in excess of about 1.65 mm., and (3) at least 25% have at least one transverse dimension in excess of about 6.7 mm., the lengthwise dimensions of the chips being substantially the same as the original chips;

cooking the shredded product in a liquor consisting essentially of sodium hydroxide alone or in combination with sodium sulphide at constant temperature, the liquor containing from 70 to 90 grams Na_2O per liter and having a sulphidity ranging from 0 to 35%, the chips and liquor being maintained at a constant temperature ranging from 162° to 178° for a period

of from 5 to 40 minutes to produce a dissolving pulp, separating the liquor from the dissolving pulp and adjusting the concentration of said liquor so that it contains from 20 to 55 grams Na_2O per liter and has a sulphidity of 0 to 35%; cooking other subdivided chips of the above-mentioned size in the liquor at a constant temperature ranging between 170° and 190° C. for a period of from 10 to 75 minutes to produce a papermaking pulp.

10. A process for digesting cellulose fiber-bearing material, such as wood chips, with a cooking liquor to produce a pulp for papermaking or dissolving purposes, including the steps:

subdividing green chips of fiber-bearing materials having a moisture content of from about 20% to about 50% by shredding the chips along the grain to produce a shredded product consisting of particles of which (1) a substantial proportion have at least one transverse dimension in excess of about 1.65 mm. and no transverse dimension greater than about 6.7 mm., (2) not more than about 5% have no transverse dimensions in excess of about 1.65 mm., and (3) at least 25% have at least one transverse dimension in excess of about 6.7 mm., the lengthwise dimensions of the chips being substantially the same as the original chips;

cooking the shredded product by a batch, acid bisulphite process in a liquor containing from 4.0% to 6.0% total SO_2 and 0.8% to 1.6% combined SO_2 , the basic ion used to form the bisulphite being selected from the group consisting of sodium, calcium, magnesium or ammonium, allowing from 30 to 120 minutes for particles and liquor to reach a maximum temperature of between 148° and 165° C., then cooking at this constant temperature for from 30 to 150 minutes.

11. A process for digesting cellulose fiber-bearing material, such as wood chips, with a cooking liquor to produce a pulp for papermaking purposes, including the steps:

subdividing green chips of fiber-bearing materials having a moisture content of from about 20% to 50% by shredding the chips along the grain to produce a shredded product consisting of particles of which (1) a substantial proportion have at least one transverse dimension in excess of about 1.65 mm. and no transverse dimension greater than about 6.7 mm., (2) not more than about 5% have no transverse dimensions in excess of about 1.65 mm., and (3) at least 25% have at least one transverse dimension in excess of about 6.7 mm., the lengthwise dimensions of the chips being substantially the same as the original chips;

cooking the shredded product by a batch, acid bisulphite process in a liquor containing from 4.0% to 6.0% total SO_2 and 0.8% to 1.6% combined SO_2 , the basic ion used to form the bisulphite being selected from the group consisting of sodium, calcium, magnesium or ammonium, allowing from 30 to 120 minutes for chips and liquor to reach a maximum temperature between 148° and 165° C., then cooking at this constant temperature for from 10 to 100 minutes and then mechanically fibrating the cooked pulp to reduce partially cooked particles to fiber.

12. A process for digesting cellulose fiber-bearing material, such as wood chips, with a cooking liquor to produce a pulp for papermaking or dissolving purposes, including the steps:

subdividing green chips of fiber-bearing materials having a moisture content of from about 20% to about 50% by shredding the chips along the grain to produce a shredded product consisting of particles of which (1) a substantial proportion have at least one transverse dimension in excess of about 1.65 mm. and no transverse dimension greater than about 6.7 mm., (2) not more than about 5% have no transverse dimensions in excess of about 1.65 mm.,

and (3) at least 25% have at least one transverse dimension in excess of about 6.7 mm., the lengthwise dimensions of the chips being substantially the same as the original chips;

continuously cooking the shredded product in an acid bisulphite liquor containing from 4.0% to 6.0% total SO_2 and 0.8% to 1.6% combined SO_2 , the basic ion used to form the bisulphite being selected from the group consisting of sodium, calcium, magnesium or ammonium, the chips and liquor being maintained at a constant temperature between 148° and 165° C. for a period between 45 and 120 minutes.

13. A process for digesting cellulose fiber-bearing material, such as wood chips, with a cooking liquor to produce a pulp for papermaking or dissolving purposes, including the steps:

subdividing green chips of fiber-bearing materials having a moisture content of from about 20% to about 50% by shredding the chips along the grain to produce a shredded product consisting of particles of which (1) a substantial proportion have at least one transverse dimension in excess of about 1.65 mm. and no transverse dimension greater than about 6.7 mm., (2) not more than about 5% have no transverse dimensions in excess of about 1.65 mm., and (3) at least 25% have at least one transverse dimension in excess of about 6.7 mm., the lengthwise dimensions of the chips being substantially the same as the original chips;

impregnating the shredded product with a dilute bisulphite solution whose basic ion is selected from the group consisting of sodium, calcium, magnesium or ammonium, the concentration of this impregnating solution being between 0.8% and 1.6% combined SO_2 , 1.6% to 3.2% total SO_2 ; continuously cooking the impregnated particles in an acid bisulphite liquor containing 4.0% to 6.0% total SO_2 and 0.8% to 1.6% combined SO_2 , the basic ion used to form the bisulphite being selected from the group consisting of sodium, calcium, magnesium or ammonium, the particles being maintained at a constant temperature in the range of between 148° and 165° C. for a period between 45 and 120 minutes.

14. A process for digesting cellulose fiber-bearing material, such as wood chips, with a cooking liquor to produce a pulp for papermaking purposes, including the steps:

subdividing green chips of fiber-bearing materials having a moisture content of from about 20% to about 50% by shredding the chips along the grain to produce a shredded product consisting of particles of which (1) a substantial proportion have at least one transverse dimension in excess of about 1.65 mm. and no transverse dimension greater than about 6.7 mm., (2) not more than about 5% have no transverse dimensions in excess of about 1.65 mm., and (3) at least 25% have at least one transverse dimension in excess of about 6.7 mm., the lengthwise dimensions of the chips being substantially the same as the original chips;

continuously cooking the shredded product in an acid bisulphite liquor containing from 4.0% to 6.0% total SO_2 and 0.8% to 1.6% combined SO_2 , the basic ion used to form the bisulphite being selected from the group consisting of sodium, calcium, magnesium or ammonium, the chips and liquor being maintained at a constant temperature in the range of 148° to 165° C. for a period between 20 and 100 minutes and then mechanically fibrating the cooked pulp to reduce partially cooked particles to fiber.

15. A process for digesting cellulose fiber-bearing material, such as wood chips, with a cooking liquor to produce a pulp for papermaking purposes, including the steps:

subdividing green chips of fiber-bearing materials hav-

ing a moisture content of from about 20% to about 50% by shredding the chips along the grain to produce a shredded product consisting of particles of which (1) a substantial proportion have at least one transverse dimension in excess of about 1.65 mm. and no transverse dimension greater than about 6.7 mm., (2) not more than about 5% have no transverse dimensions in excess of about 1.65 mm., and (3) at least 25% have at least one transverse dimension in excess of about 6.7 mm., the lengthwise dimensions of the chips being substantially the same as the original chips;

continuously cooking the shredded product in a bisulphite liquor containing from 3.0% to 8.0% total SO_2 and 1.5% to 4.0% combined SO_2 , the basic ion used to form the bisulphite salt being selected from the group consisting of sodium, calcium, magnesium and ammonium, the chips and liquor being maintained at a constant temperature in the range of 148° to 180° C. for a period between 45 and 180 minutes.

16. A process for digesting cellulose fiber-bearing material, such as wood chips with a cooking liquor to produce a pulp for papermaking purposes, including the steps:

subdividing green chips of fiber-bearing materials having a moisture content of from about 20% to about 50% by shredding the chips along the grain to produce a shredded product consisting of particles of which (1) a substantial proportion have at least one transverse dimension in excess of about 1.65 mm. and no transverse dimension greater than about 6.7 mm., (2) not more than about 5% have no transverse dimensions in excess of about 1.65 mm., and (3) at least 25% have at least one transverse dimension in excess of about 6.7 mm., the lengthwise dimensions of the chips being substantially the same as the original chips;

impregnating the shredded product with a dilute bisulphite solution whose basic ion is selected from the group consisting of sodium, calcium, magnesium and ammonium, the concentration of the impregnating solution being between 0.8% and 3.0% combined SO_2 , 1.6% and 6.0% total SO_2 , continuously cooking the impregnated particles in a bisulphite liquor containing from 3.0% to 8.0% total SO_2 and 1.5% and 4.0% combined SO_2 , the basic ion used to form the bisulphite salt being selected from the group consisting of sodium, calcium, magnesium and ammonium, the chips and liquor being maintained at a constant temperature in the range of 148° and 180° C. for a period between 30 and 150 minutes.

17. A process for digesting cellulose fiber-bearing material, such as wood chips, with a cooking liquor to produce a pulp for papermaking purposes, including the steps:

subdividing green chips of fiber-bearing materials having a moisture content of from about 20% to about 50% by shredding the chips along the grain to produce a shredded product consisting of particles of which (1) a substantial proportion have at least one transverse dimension in excess of about 1.65 mm. and no transverse dimension greater than about 6.7 mm., (2) not more than about 5% have no transverse dimensions in excess of about 1.65 mm., and (3) at least 25% have at least one transverse dimension in excess of about 6.7 mm., the lengthwise dimensions of the chips being substantially the same as the original chips;

cooking the shredded product by a batch, neutral sulphite semichemical process in a liquor containing 20 to 75 grams as Na_2O per liter, of which 60% to 80% is present as sodium sulphite, the remainder as sodium carbonate, the chips and liquor being brought to a maximum temperature ranging between 165°

and 178° C. in from 30 to 90 minutes, this maximum temperature then being maintained constant for a period between 100 and 240 minutes and then mechanically fibrating the cooked particles to reduce partially cooked particles to pulp.

18. A process for digesting cellulose fiber-bearing material, such as wood chips, with a cooking liquor to produce a pulp for papermaking purposes, including the steps:

subdividing green chips of fiber-bearing materials having a moisture content of from about 20% to about 50% by shredding the chips along the grain to produce a shredded product consisting of particles of which (1) a substantial proportion have at least one transverse dimension in excess of about 1.65 mm. and no transverse dimension greater than about 6.7 mm., (2) not more than about 5% have no transverse dimensions in excess of about 1.65 mm., and (3) at least 25% have at least one transverse dimension in excess of about 6.7 mm., the lengthwise dimensions of the chips being substantially the same as the original chips;

continuously cooking the shredded product in a neutral sulphite liquor containing 20 to 75 grams as Na_2O per liter, of which 60% to 80% is present as sodium sulphite, the remainder as sodium carbonate, the chips and liquor being held at a constant temperature ranging between 185° and 200° C. for a period between 20 and 90 minutes, then mechanically fibrating the cooked particles to reduce partially cooked particles to fiber.

19. A process for digesting cellulose fiber-bearing material, such as wood chips, with a cooking liquor to produce a pulp for papermaking purposes, including the steps:

subdividing green chips of fiber-bearing materials having a moisture content of from about 20% to about 50% by shredding the chips along the grain to produce a shredded product consisting of particles of which (1) a substantial proportion have at least one transverse dimension in excess of about 1.65 mm. and no transverse dimension greater than about 6.7 mm., (2) not more than about 5% have no transverse dimensions in excess of about 1.65 mm., and (3) at least 25% have at least one transverse dimension in excess of about 6.7 mm., the lengthwise dimensions of the chips being substantially the same as the original chips;

impregnating the shredded product with cooking liquor containing 20 to 75 grams Na_2O per liter, of which 60% to 80% is present as sodium sulphite, and the remainder as sodium carbonate, draining off excess impregnating liquor after impregnation; cooking the impregnated particles in cooking liquor similar to the impregnating liquor at constant temperature in the range of 180° to 200° C. for a period between 20 and 90 minutes and then mechanically fibrating the cooked particles to reduce partially cooked particles to pulp.

References Cited by the Examiner

UNITED STATES PATENTS

1,203,511	10/16	Embree	162—28
2,904,460	9/59	Nolan	162—28

FOREIGN PATENTS

830,048	5/38	France.
---------	------	---------

OTHER REFERENCES

Hagglund: Significance of Chip Sizes in Sulphite Cooking, C. A., 1941; CA 36, 6013.

Montigny: Investigation of Physics—Chemical Factors Which Influence Sulphite Cooking, Forest Service Bulletin No. 87, Dept. of Interior Canada, page 33 relied on.

DONALL H. SYLVESTER, *Primary Examiner*.

MORRIS O. WOLK, WILLIAM B. KNIGHT,

Examiners.