

Jan. 17, 1933.

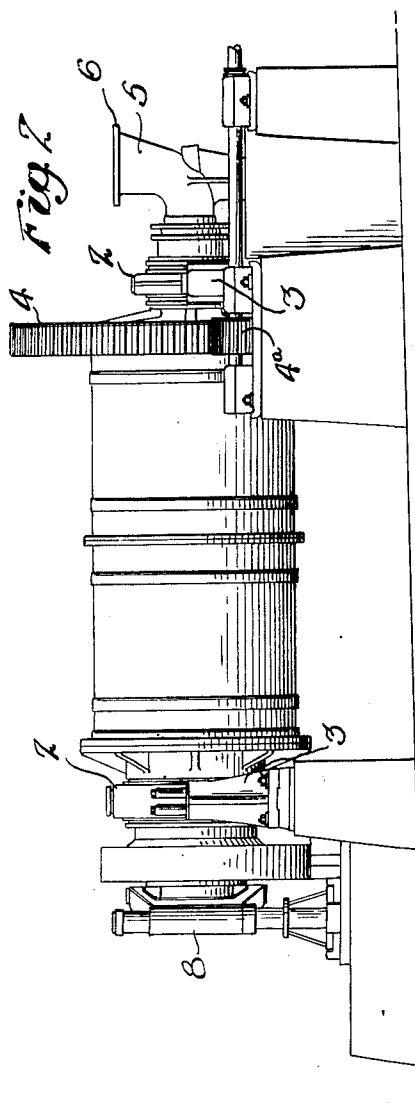
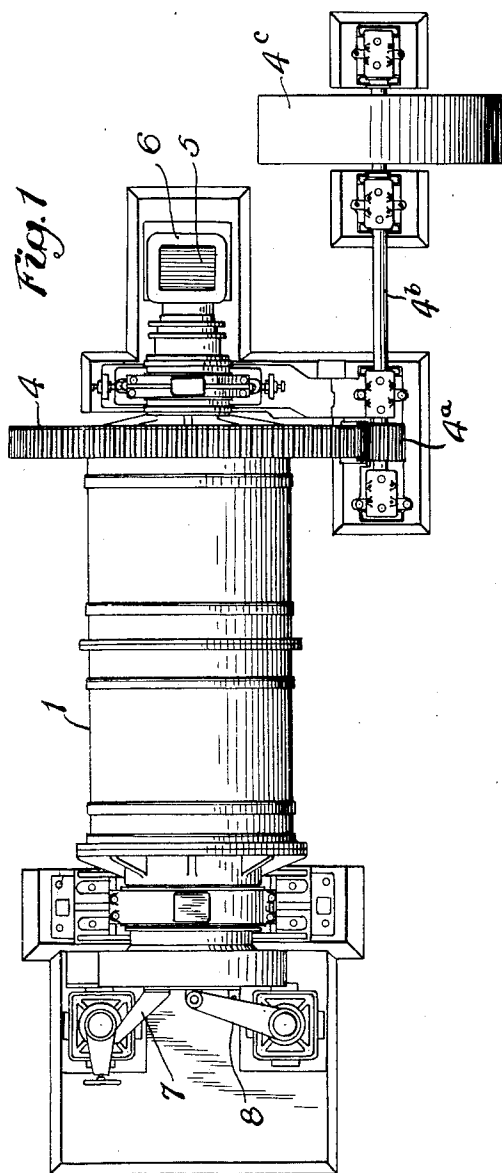
S. D. WELLS

1,894,577

PRODUCTION OF FIBER

Filed Sept. 17, 1927

3 Sheets-Sheet 1



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Inventor

By William L. Symons
his Attorney

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3 Sheets-Sheet 2

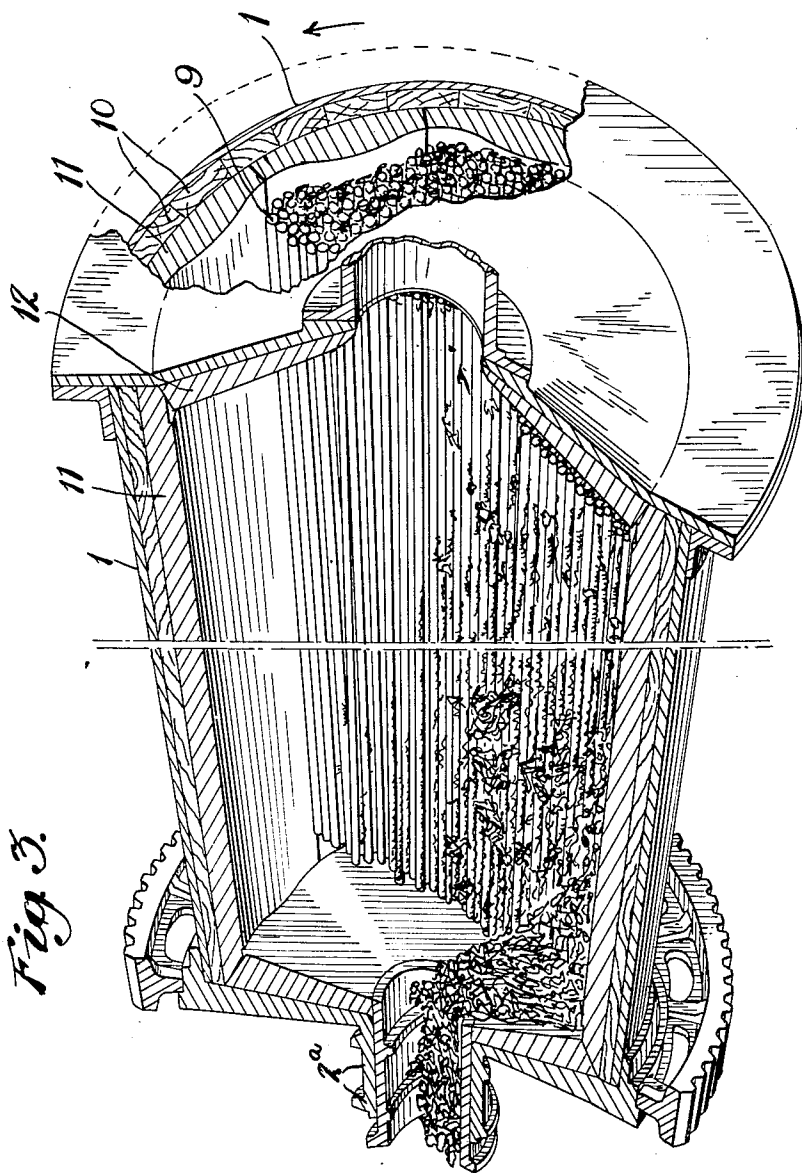


Fig. 3.

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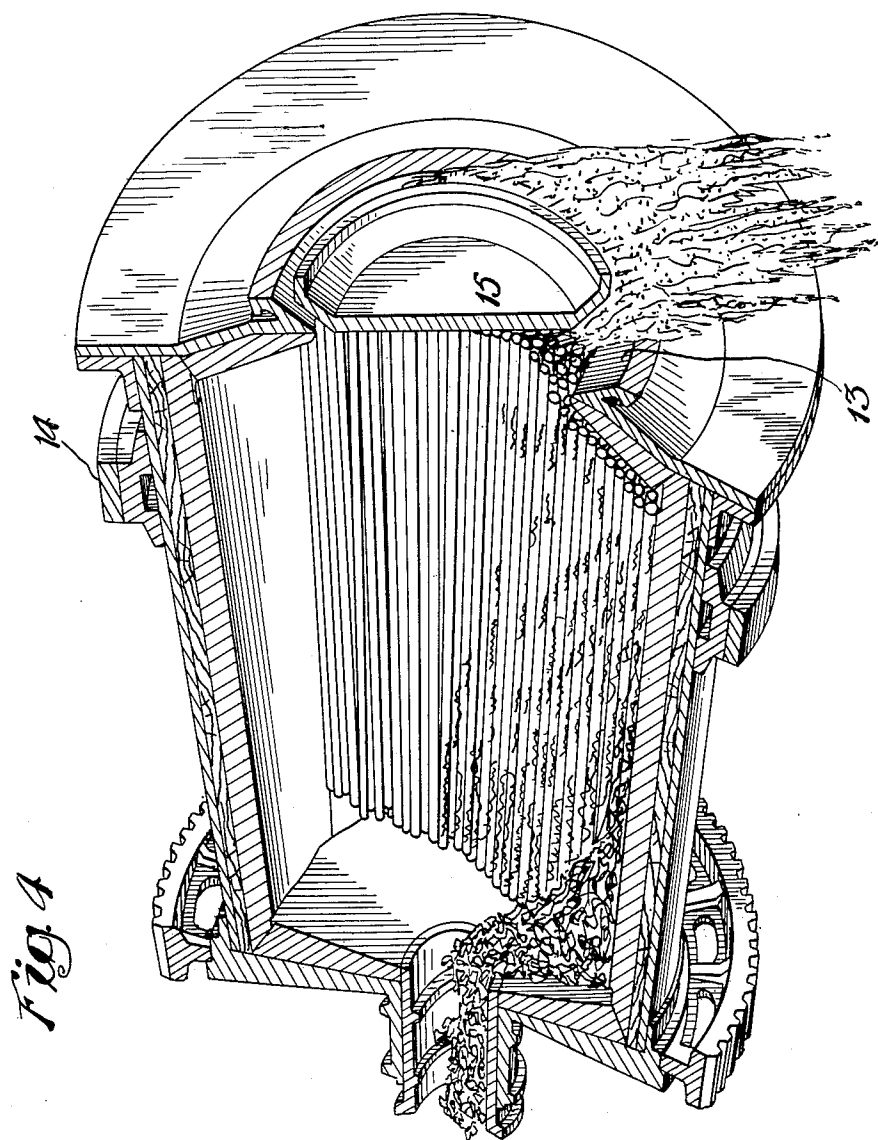
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PRODUCTION OF FIBER

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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

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PRODUCTION OF FIBER

Application filed September 17, 1927. Serial No. 220,201.

This invention relates to the production of fiber suitable for manufacture of paper and pertains particularly to the treatment of wood and other vegetable fibrous material by the steps of the particular process and within a certain apparatus, both of which comprise a part of the present invention.

The process provides for the treatment of softened woody material and which has been converted into a ligno-cellulosic intermediate product by pounding and rubbing such previously prepared material into pulp in a particular way without breaking the fibers and without the reduction to fragments of more than an insignificant proportion of the fibers and cells.

The broad conception of this procedure and the apparatus therefor has been set forth in my application for patent, Serial No. 49,461, filed August 10, 1925 issued as Patent No. 1,654,624, dated Jan. 3, 1928. In that application was described a treatment and apparatus in which there is a rotatable drum structure within which the pulp is tumbled, pounded and beaten by intermingled contact with a plurality of rods, which extend in parallel relation lengthwise of the axis of the drum and are free to roll and tumble therein under the influence of the rotary movement of the drum. With this improved pulping apparatus, the length of the fiber is maintained and the fibers are not disintegrated into the sawdust like particles commonly produced and observed in processes in which the grinding apparatus includes a rotary abrading element or cutting element.

Since the invention described in application Serial No. 49,461, I have now discovered that certain new factors and apparatus details make it possible to obtain markedly beneficial results while operating under substantially the same general procedure as described in application Serial No. 49,461. It has now been determined that certain consistencies of pulp, that is, ratios by weight

of dry fiber to water, contribute greatly to the efficiency of the pulping operation. A higher content of pulp to liquid, as contrasted to the usual beater practice, now not only is desirable, but preferable, according to this invention. This is in striking contrast to the pulping and beater practice in which mills operating with consistencies greater than five parts by weight of dry fiber to 100 parts by weight of water have been extremely rare. Ordinarily, consistencies of less than five per cent have been used in the types of equipment generally standard in this art.

More specifically, by this invention, it has been found that in using the rod mill for preparing pulp, best results are obtained when the ratio of dry pulp fiber to water is maintained within a certain well defined optimum range, namely, 7.5 to 9.5, which is chiefly noteworthy because the percentages within this range are higher than those commonly in use heretofore in other pulping practice. The ratios provided by the present invention result in an improved pulp and tend to reduce wear in the machine. Further, and even more specifically, by this invention it has been determined that rod mill treatment of pulp and fibrous material is best conducted with a lower limit of approximately five parts of dry fiber to 100 parts of liquid. Other forms of apparatus commonly function better with lower ratios and a smaller portion of fibrous material. It has now been determined that too low a ratio of fiber to liquid tends to cause waste of power by reason of the rods grinding against each other and on the interior of the drum. At the same time injury is done to the fibers on which the strength and toughness of the ultimate product depend. It is noticeable that other forms of equipment may satisfactorily be operated on fibrous mixtures having a low proportion of fiber and that mills operating with consistencies greater than five parts by weight of dry fiber per 100 parts of water are extreme-

ly rare although this five per cent ratio is the lower limit for the procedure according to this present invention.

The following table shows how the strength of the product is increased by increasing the consistency within certain limits, with the same rate of feed of material to the mill and the same power consumption:

10	Consistency of pulp, per cent	Mullen test, strength factor, point per pound
15	4.5 -----	5.02
	6.34 -----	5.42
	7.32 -----	6.07
	8.55 -----	6.06
	9.29 -----	5.79

Not only was the strength of the pulp as it left the mill improved by using consistencies above five per cent but the ultimate strength developed by subsequent equipment was increased.

In operating this invention, it is noteworthy that a peculiar condition exists wherein a mass of freely falling and tumbling rods fall through a mixture of fiber and liquid and which mixture exercises a buoyancy resistant to the falling action of the rods. This buoyancy is marked and is more or less proportionate to the high level of stock maintained in the mill. In the accompanying drawings, there is illustrated a mill capable of working on stock of relatively high consistency and with great effectiveness.

As pointed out in application 49,461, especially does this invention relate to the mechanical phases of fiber producing processes and to the resulting fibrous material suitable for paper manufacture and for other purposes, obtained from wood as for example, after the original material has been prepared chemically by boiling the same under pressure in the presence of aqueous solutions of caustic soda and sodium sulphide, caustic soda and sulphur, or sodium sulphite and sodium carbonate of suitable concentration to soften the woody material and to form the ligno-cellulosic intermediate product above mentioned.

At the present state of the pulp makers' art the processes used may be divided into two groups, the mechanical and the chemical. The mechanical process consists essentially of pressing blocks of wood against a revolving grindstone in the presence of water and the wood is reduced to pulp by grinding and the frictional heat developed. In this process the action is so severe that comparatively few of the fibers survive in their entity and a large portion of the pulp consists of fragments of single fibers or of bundles of fibers. In the chemical processes the wood is cut to chips and digested under pressure in aqueous solutions of the bisulphites of the

alkaline earths and sulphurous acid or caustic soda or caustic soda and sodium sulphide or sodium sulphite. The digestion is carried to such a point that over fifty per cent of the wood substance is dissolved and a product testing over 90% cellulose is left. In these processes the ultimate fibers are intact, but the bond between them has been removed so that they separate with the slightest mechanical agitation. By ultimate fiber is meant the elongated cells which are attached longitudinally and cemented together radially by incrusting matter consisting largely of lignin and hemicelluloses. Their entity is readily discernible under the microscope and their length is approximately 100 times or more their diameter.

In the present improvement the wood is also cut to chips and the chips subjected to aqueous solutions of suitable chemicals of elevated temperatures after first being subjected to an impregnation treatment. The digestion however is only carried to the point that the middle lamella or cementing material between the fibers is softened, but not completely dissolved. The softened chips are then capable of reduction to their ultimate fibers and cells by suitable pounding or rubbing or a combination of both in accordance with the present invention. A pulp is obtained that has the general appearance of pulp obtained by the chemical processes mentioned, but instead of a yield of from 40 to 50 per cent being obtained, a yield of from 60 to 85 per cent is realized, depending on the species of wood and the severity of the treatment. While these pulps are similar in appearance to what are generally known as chemical pulps they have distinct chemical characterizations, as described in detail in said application 49,461.

An important element of novelty in the present process as well as in Serial 49,461, is the use of mechanical disintegrating types of apparatus in the process which have never before been used on this sort of material for the purpose. The beaters, refining engines or attrition mills fitted with rigid bars or blades which have been used in the paper making art have been found to produce a very unsatisfactory material when applied to softened woody material. Vascular bundles and fragments of the medullary rays are produced which resist reduction longitudinally and appear in the sheet of paper formed from the resultant product as granular sawdust like specks or slivers which render it practically useless for the purpose intended. If the grinding is carried on to the point where these particles have been satisfactorily reduced in size the fibers are also reduced in length until they have lost their power of imparting the desired strength to the paper. On the other hand when properly reduced by pounding or rubbing these fragments do not

appear in the finished product and a sheet of uniform texture may be obtained. Not only may this pounding or rubbing action be applied to softened woody material, but it may be applied with excellent results to the beating of the standard chemical pulps or rag or rope or jute pulps of commerce. The rod mill has been found most satisfactory for this purpose.

The process is carried out with the use of particular apparatus which is used for providing the pounding or rubbing action and which apparatus is identified, as above mentioned, as a rod mill. The structure of this apparatus will be briefly described by reference to the accompanying drawings in which:—

Figure 1 represents a top plan view of an elongated cylindrical drum which is mounted at opposite ends in suitable supporting bearings, and which is shown as having adjacent one end a large gear encircling it, the teeth of which are in mesh with a smaller gear driven from any suitable source of power;

Figure 2 is a side elevation of the apparatus shown in Figure 1 and illustrating the intake pipe projecting upwardly at the right hand end;

Figure 3 is an enlarged sectional view of the drum shown in Figures 1 and 2 looking from the left to right and in perspective, and showing opposite end openings of substantially the same size; and

Figure 4 is a view similar to Figure 3, but showing a different form of discharge opening at the right hand side of the view, the latter being larger than the intake opening and positioned so that a lower level of material is maintained within the drum than would be maintained in the structure shown in Figure 3.

Referring in detail to the several figures in the drawing, 1 indicates the cylindrical shell of a rotary drum which is mounted with its longitudinal axis extending substantially horizontally and supported in bearings 2 at either end on upright supports 3. If desired, the structure may be tilted slightly lower at the discharge opening, as indicated at the base line in Figure 2, thus to facilitate movement of pulp through the drum. 4 indicates a large annular gear secured to the flange at one end of the drum. In mesh with the teeth of this gear 4 is a smaller gear 4^a, which is driven by any suitable source of power through a shaft 4^b and pulley wheel 4^c.

The intake end is provided with a receiving pipe 5 illustrated at the right hand side of the Figures 1 and 2, as projecting from the line of the axis of the drum upwardly terminating with a horizontally extending flange 6 suitable for attachment to any suitable supply pipe. The discharge side of the drum leads through a portion supported in

the bearings and is provided with suitable control gates or valves, not shown in Figures 1 and 2, having control means and supporting mountings therefor indicated at 7 and 8, which are located on the exterior of the apparatus and have connections extending into the terminal end of the drum to the necessary or desired gates or valves.

Referring to the structure shown in Figure 3, the inlet end at the left is shown terminating with an end flange to facilitate a coupling between this element which is revoluble and a fixed supply pipe 5. An encircling bearing element 2^a is indicated around the receiving end and which is adapted to be mounted in the bearing 2, shown in Figures 1 and 2. This Figure 3 illustrates the position of the rods 9 within the drum during the movement of the drum in the direction of the arrow. One end of the view of Figure 3 is broken away to show the manner of construction. The metal shell 1 of the drum is lined with any suitable material, preferably wooden planks 10. On the interior is a suitable wear surface formed of longitudinal elements 11 which may be arcuate to conform to the outer curvature of the drum or they may be of the "wave" type, as illustrated in Figures 3 and 4. These elements 11 are preferably of substantial metal. At the ends of the drum and on the interior are end wear elements 12, also preferably of metal and which are illustrated as providing a sloping surface tending to converge at the drum side and sloping away axially. In this way, it is possible to avoid positioning the rods with their ends extending in substantially the same plane vertically, since such a position tends to render it difficult for the fiber material to be treated to enter between the rods, whereas, by sloping the inner surfaces of the end walls as illustrated, the ends of the rods lie in different positions and the fibrous material can extend over a portion of a rod at the intake end and then as the upper rods fall downward such material is caught between the rods and ultimately works its way to the opposite end of the drum, receiving as it progresses the desired treatment.

In the apparatus illustrated in Figure 4, the outlet end opening is larger than the inlet end opening and has peripheral opening walls indicated at 13. In this arrangement, it may be desirable to avoid the use of a relatively small trunnion mounting such as indicated at 2 and 3 in Figures 1 and 2 and at the left hand end of the view of Figure 4, and thus a ring 14 may be used encircling the drum. Such a structure would normally be mounted on supporting rollers, not illustrated. An optional arrangement would be provided by extending the wall 13 axially and providing suitable trunnion support therefor and which details are not essential to the present invention. An important fea-

ture in the arrangement shown in Figure 4 is the use of an end rod retaining plate 15, which is supported from the exterior and located in the opening provided by the wall 13 but spaced therefrom, as shown in Figure 4, so that pulp discharging from the drum may have room to pass between the plate 15 and the revolving surface of the walls 13. The plate 15 has a flat inner surface next adjacent the rods and this plate resists the tendency of the rods to work with the pulp toward the outlet opening. One of the features of the present invention from a process standpoint is dependent on an operation made possible by the respective heights of the overflow edge of the surface 13 as compared to the height of the rods within the drum and the height of the material as it enters through the intake end and also the rate of flow of the material as it enters. With the arrangement illustrated in Figure 4, it is possible to have the rods positioned with their upper level higher than the overflow edge at the discharge opening, and thus it is possible to insure positive treatment by rod action on all material entering through the intake opening. Contrasted to such an arrangement would be apparatus in which the rods were as far below the overflow edge of the discharge opening as they are below the edge at the receiving opening, since there would thus be a chance for material to flow over the top of the rods from intake to outlet without being required to pass between the rods. The plate 15 may be used to partially close the outlet opening and thus tend to restrict the discharge of treated pulp from the drum and correspondingly increase the period of treatment. The plate 15 may be supported on the inner end of arms 7 or 8 as indicated diagrammatically in Figures 1 and 2.

The intake end receives chips through the pipe 5 and these chips may or may not have been previously softened, but preferably this material is softened in accordance with the several steps outlined in the description hereinafter provided. During the revolution of the drum 1 the material works its way gradually toward the outlet end and discharges through the opening 13, the rate of discharge being proportional with the rate of intake. A plurality of rods 9 in number sufficient to half fill the drum lie along the bottom and on top of each other. These rods are preferably from two to four inches in diameter and have a length about two inches shorter than the inside length of the drum. The inner lining of the drum may have a contour variable according to the type of fiber to be treated. A so-called "wave" type shell liner has operated to advantage, and in this particular form there are occasional rounded humps which extend lengthwise of the shell or drum wall and aid in lifting the rods and fibrous material from the bottom during the revolution

of the structure. The smooth surface of the wave type lining is useful in maintaining uninjured the full length of the fibers, contrasted to which angular linings tend to cut and destroy the fibers.

During the operation of the apparatus, the rods and fibrous material are lifted upward with the movement of the casing and the entire mass of fibrous material intermixed with the rods rolls from top to bottom of the pile toward the opposite side of the drum. This rolling and tumbling movement of the rods serves to rub, pound and beat the previously softened vegetable fiber material into a relatively open condition, thus providing a satisfactory pulp. It is obvious that there is little if any cutting action detrimental to the felting property of the fibers, and it is also obvious that as long as there are any unreduced bundles or lumps in the mass, they will receive substantially the entire action of the rods and correspondingly the portions that are sufficiently reduced will be protected by the lumps and will escape further reduction. It is therefore obvious that the rod mill is selective in its action and consequently attains its results with the least expenditure of energy on material already in proper condition. It is thus also different from positively operated types of equipment now in use for beating or grinding paper pulp.

The action of the rods in the rod mill on the particles of vegetable material may be compared to the treatment which the particles would receive on an inclined surface while pounding elements roll from top to bottom across the inclined surface, rolling, crushing and pounding the particles as the rods tumble from top to bottom. The pile of rods maintains more or less a uniform inclined surface, but as regards the relation of one rod to another, the mass or pile of rods is in constant transition, the rod elements moving from the bottom of the pile toward the crest of the pile, being carried upward by the rotation of the casing, successive rods, after reaching the crest of the pile, being carried so high that the uppermost rod is carried so far that it is no longer retained by the rods next beneath, but falls downward across the inclined surface of the more slowly moving rods until it reaches the side of the pile and comes to rest adjacent the casing on the side thereof opposite to that from whence it started. In the constant transition of individual elements of the pile of rods from bottom to top, and thence more rapidly across the inclined face of the pile of rods, it will be obvious that the respective rods making up the inclined face also are moving downward, although the largest number of the rods thus forming the inclined surface move more slowly than the ones which are carried to the extreme crest or top of the pile, and which tumble across the surface to the opposite side. It will also

be obvious that the plurality of rods composing the inclined surface provide a corrugated effect. Accordingly, particles of vegetable material appearing on the inclined surface of the pile of rods are subjected to the impact of the rapidly moving rods as they are released from the top side and roll across the corrugated surface toward the lower side, striking and rolling across the outer side of each of the individual elements thus forming the corrugated surface. It will also be obvious that not only will the particles of vegetable material be given a peculiar treatment in between the rods and within the mass of the rods by reason of the constant transition movement of the shifting body of rods, but also that an unusual impact treatment is given to all particles of the vegetable material which lie on the upper surface, and such upper particles receive an impact treatment due to the direct contact of a freely moving, falling, tumbling body.

The following procedure may be used in treating fresh wood fibrous material to produce the ligno-cellulosic material described. The wood is first converted to chips in the manner used in chemical pulp mills and charged into a digester. They are then impregnated by steaming and then forcing the softening solution into them by filling the digester therewith and producing hydrostatic pressure by means of a pump, steam, air, or any other method known to the art. After impregnation for half an hour or more at 100 pounds pressure the softening solution will be found to have practically penetrated the chips and the excess over that required for softening is removed. Using 10 parts of sodium sulphite and 4 parts of sodium bicarbonate per 100 parts dry weight of gum chips gave excellent results. The substitution of sodium carbonate for bicarbonate was also satisfactory. The substitution of 2 parts caustic soda for the bicarbonate gave satisfactory results with loblolly pine. For pulps from the pines where greater strength is desired 8 parts of caustic soda and one part of sulphur was satisfactory. 8% calcium bi-sulphite and 2% sulphurous acid gave good results with tamarack. It can thus be seen that a wide range of chemicals may be used. This impregnation feature is important because it makes possible the softening of the wood uniformly through its thickness. By the term "uniform" is meant the even softening to substantially the same degree from the exterior to the center of each piece of wood. Thus, the chips after treatment are practically as soft at their centers as they are on the outside. Without previous impregnation and with the use of the direct cook only, the woody material is likely to become damaged by over cooking on the exterior portions before the interior is adequately softened. Thus, with ordinary cooking methods, the

undigested chips will be almost completely cooked on the outside, and in extreme cases, the center will be bright wood, not even discolored by the cooking liquor. Accordingly, in view of the fact that the particular subsequent mechanical separation of this invention requires uniform softening, it becomes extremely important that the softening step be conducted in accordance with the procedure herein prescribed.

After the excess of liquor has been withdrawn the contents of the digester are heated until a temperature of over 120° C. has been attained and the contents held thereat until the desired softening has taken place. In the first three instances two hours at 160° C. was sufficient. Four hours at 160° C. was sufficient in the fourth, and six hours coming up to a temperature of 120° C. was sufficient in the last. The contents are then removed from the digester and reduced to ultimate fibers by passing through the rod mill of the present invention.

One of the features of this present invention, as indicated earlier in this specification, is the ratio between the amount of fiber to the amount of liquid which has now been found an important factor. As indicated hereinbefore, this ratio extends from five parts and above up to 9.5 parts of dry fiber by weight to each one hundred parts of fluid. When such a mixture is subjected to the rod mill treatment, the most advantageous conditions are present. The optimum range for this rod mill treatment is about 7.5 parts of dry fiber to each one hundred parts of liquid. This amount of fiber is markedly high, as compared to the amount of fiber in mixtures heretofore treated by the usual grinders and beaters. The pulps produced are then washed and prepared in suitable form by the customary steps used in the art. In the use of rubbing and pounding devices screens are desirable to allow the ultimate fibers or cells to pass on and return the material insufficiently disintegrated for additional rubbing and pounding thereby forming a closed system.

Not only is the rod mill adapted to pulping wood but it is also adapted for use in pulping cooked or softened cereal straws, and also bamboo, cornstalks, bagasse from sugar cane, sorghum, flax straw, hemp, alfagrass, palmetto, palm, saw grass, cane, and in fact almost any of the fibrous plant materials may be so treated. Not only may softened fibrous plant material be treated in the rod mill, but the softening can be accomplished while the material is being rubbed or pounded by admitting hot water or blowing steam into the mill to maintain an elevated temperature and at the same time admit sodium carbonate, milk of lime or any of the known softening agents or mixtures thereof with the raw fiber.

Not only is the rod mill treatment suitable for rubbing apart the fibers in softened fibrous material or for both softening and rubbing where the material is to be used for paper manufacture in the unbleached and unpurified condition, but it may be used where the product therefrom is to be further purified by washing, treatment with chlorine gas or chlorine water, boiled with sodium sulphite, sodium carbonate, sodium hydroxide or some similar compound capable of dissolving the products of chlorination. The fibrous product may then be subjected to a repetition of the same treatment and then bleached by customary methods or when not necessary the repetition of the chlorination treatment may be omitted. The purification processes outlined above are not claimed except insofar as the rod mill is used to prepare the material into proper condition without which these processes are unsatisfactory. The use of the rod mill in preparing lime cooked straw for paper products or for further purification by means of chlorination methods is particularly important.

I claim:—

In the production of fibers from vegetable material for use in making paper, the method of treating material, which has been uniformly softened but not pulped, which method consists in separating the fibers of said softened material by pounding the same between parallel pounding surfaces of a plurality of elongated pounding elements which extend in substantially constant parallel relation and which freely fall in intermingled contact with the material and impact upon particles of the material, and discharging said material at a point below the upper level of said pounding elements, the treatment being conducted under conditions in which the material treated includes fiber in proportions of at least five parts and not more than 9.5 parts to 100 parts of fluid by weight.

In testimony whereof I affix my signature.

SIDNEY D. WELLS.

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