June 5, 1934. J. TRAQUAIR 1,961,405

PAPER MANUFACTURE

Filed Aug. 17, 1928 3 Sheets-Sheet 1

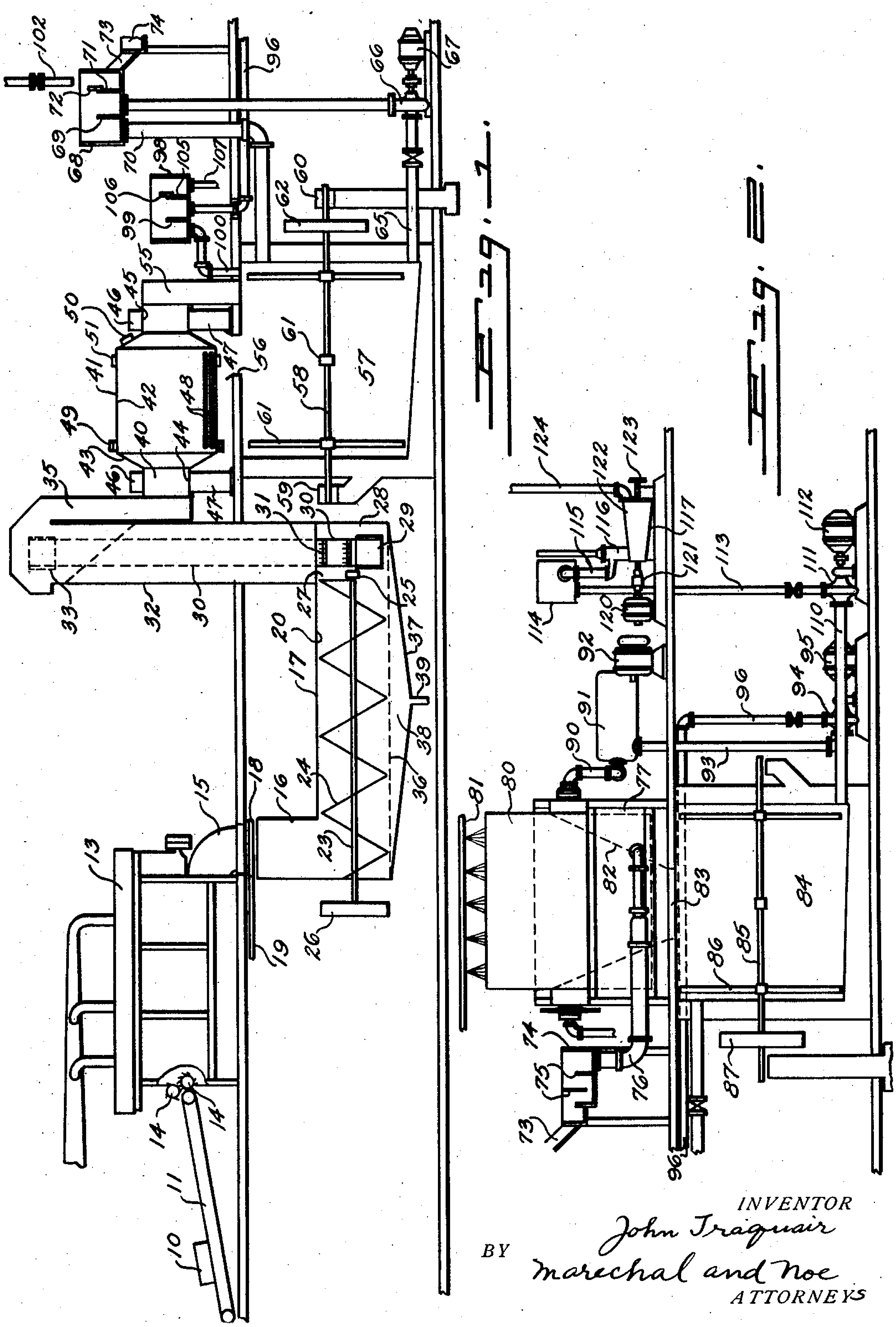

Fig. 1.

Fig. 2.

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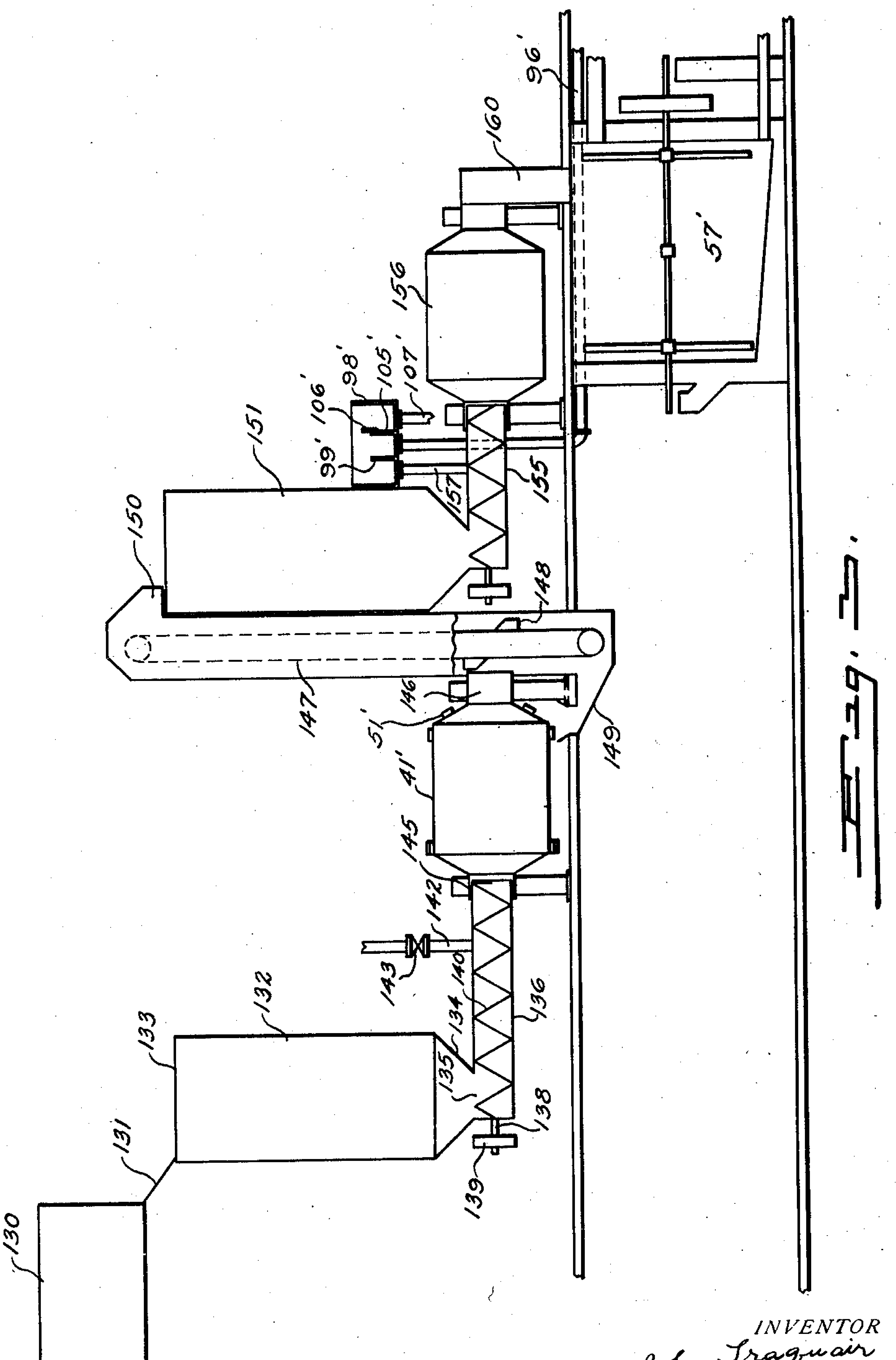

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Filed Aug. 17, 1928 3 Sheets-Sheet 3

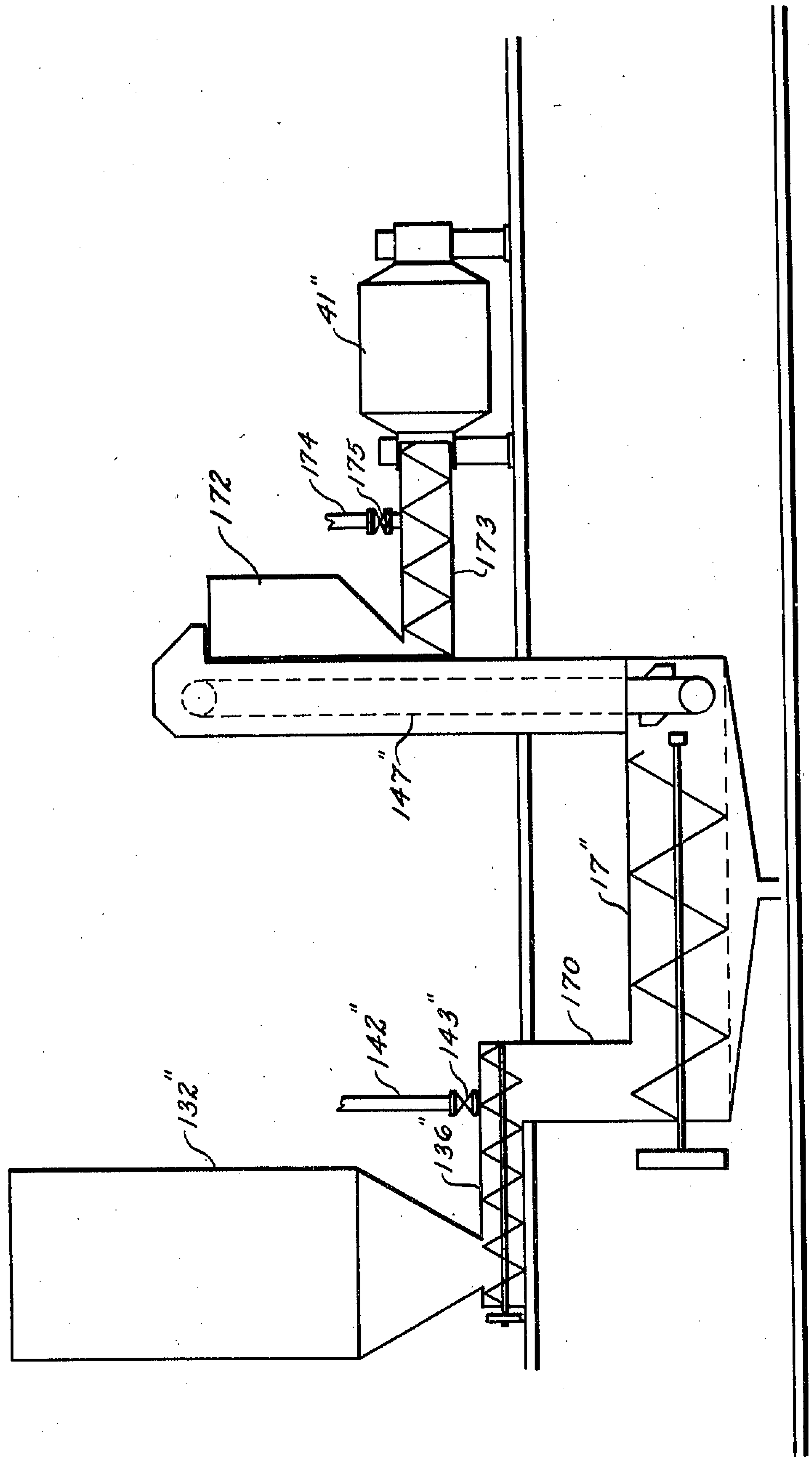

Fig. 4.

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UNITED STATES PATENT OFFICE

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PAPER MANUFACTURE

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Application August 17, 1928, Serial No. 300,207

28 Claims. (Cl. 92—7)

This invention relates to the manufacture of paper, and particularly to the manufacture of various classes of board, such as container board, corrugated board, egg case fillers and the like, and to the manufacture of various grades of wrapping paper.

One of the principal objects of the invention is to provide a superior method of, and apparatus for, treating raw fibrous materials such as various classes of wood, straw, cereal grasses, cane, bamboo, reeds and the like in the manufacture of paper.

Another object of the invention is to provide such a method and apparatus which function to produce a larger yield of better grade paper-forming stock from a given quantity of raw fibrous material and at a smaller cost.

Still another object of the invention is to provide such a method and apparatus which function continuously and are self-contained, which eliminate digestion or cooking, and which admit of recovery of the chemicals used to eliminate waste and stream pollution.

Other objects and advantages of the invention will be apparent from the following description, from the drawings and appended claims.

In the drawings in which like characters of reference designate like parts throughout the several views therof,

Fig. 1 is a side elevational view, somewhat diagrammatic, of a portion of apparatus adapted particularly for the treatment of straw, cereal grasses and the like, constructed in accordance with this invention and adapted for carrying out the method of this invention;

Fig. 2 is a side elevational view, somewhat diagrammatic, of another portion of the apparatus, Figs. 1 and 2 when placed end to end disclosing the complete apparatus;

Fig. 3 is a side elevational view, somewhat diagrammatic, of apparatus constructed particularly for the treatment of wood in accordance with this invention; and

Fig. 4 is a side elevational view, somewhat diagrammatic, of a modified form of apparatus constructed particularly for the treatment of wood in accordance with this invention.

The method of the present invention is adapted for the treatment of various classes of wood, and particularly various types of waste wood as representing an economical source of supply of raw material. For example, the method is applicable to the treatment of cull lumber, shavings, waste wood from furniture and box factories, saw mill waste, leached chips from tannin extract mills, and the like. The process is more especially applicable to the various deciduous or non-resinous broad-leaf woods, also called the hard woods, such as chestnut, gum, poplar, birch and the like. The methods heretofore generally used in this country for the pulping of wood consist in cooking the wood by boiling under pressure with strong cooking liquor, such as caustic soda, bisulfites, or sodium sulfate, as exemplified in the well known soda, sulfite and kraft processes. In all these processes where the wood is subjected to cooking treatment, the yield is quite low, seldom being over 50% and generally around 40%. Furthermore, the cellulose fibers are deleteriously affected by the cooking treatment, thereby reducing their strength.

The method of the present invention is also adapted for the treatment of straw, cereal grasses, cane, bambo, reeds and the like. The term "straw" as hereinafter used is not meant to be a limitation, but merely as designating all such analogous materials. The method heretofore generally used in this country in the manufacture of strawboard consists in cooking the straw by boiling it in strong lime solution under pressure. The strawboard which is thus produced has a limited utility because of its poor color and because it is hard and brittle and of limited strength. In addition the lime appears to combine with some of the constituents present in the straw forming lime compounds which can not be effectively removed from the straw pulp, and which impart to the resulting strawboard a disagreeable odor. Furthermore, chemicals used in this method of treatment do not adapt themselves to recovery and consequently a large amount of exhausted chemicals and straw material are lost in the process. The waste material and chemicals are customarily allowed to flow into nearby streams, the resulting stream pollution being so objectionable that legislatures in many states have passed measures against such practices.

According to the present invention a method for the treatment of wood, straw and the like, in the making of paper-forming stock is provided which produces a finished paper or board free from objectionable odor, which has greater strength than paper or board made from the same raw materials by other generally used methods of treatment, which utilizes chemicals which may be recovered and thus used over and over to provide a continuous self-contained process without the production of stream polluting waste, and which gives an unusually high yield of better-grade paper-forming stock.

In accordance with this method, the raw fibrous material is first sub-divided to suitable size, and is then mechanically disintegrated in the presence of an alkaline liquor. Sub-divided fibrous material when in an alkaline condition is found to possess characteristics of softness and unusual ease of refining to a flexible pulp. With mechanical disintegration in the presence of an alkaline liquor, only relatively small percentages of the fibrous material are dissolved or lost in the process, a substantial portion of lignins and pentosans remaining in the stock, increasing the yield as well as functioning as a natural size. As representing a suitable and preferred form of disintegrator, a rod mill is shown and described herein. However, it is to be understood that any suitable disintegrating mill can be used, which functions to subject the raw material to a pounding, rubbing or shredding action, to sub-divide the material into fibers and to hydrate these fibers and adapt them for formation of a suitable sheet on the forming machine. For example, a disintegrating mill of the swing-hammer type may be used. The disintegrated pulp is then filtered and washed, and is then further reduced in a refiner, such as a Jordan, when it is ready to be passed to the paper machine.

When straw or fibrous grasses and the like are being treated it is found preferable to first subject such materials to a steeping action in an alkaline liquor to wilt and soften them. Such a steeping action may be applied to wood with good results. This is accomplished by immersing the raw fibrous material in alkaline liquor of controlled characteristics where it is steeped at a controlled temperature below the boiling point of such liquor and at substantially atmospheric pressure. The steeping liquor which is caustic in character, is so constituted that the temperature and pressure at which the steeping is carried on effects a primary softening of the bonding material holding the cellulose fibers together without a material destruction of the shape or appearance of the raw fibrous material and without any deleterious effect upon the cellulose fibers, so that by mechanical treatment the fibers may be readily separated or the raw material disintegrated. The steeped fibrous material is removed from the steeping liquor and allowed to drain until it contains a controlled amount of retained liquor still having substantial causticity when it is then subjected to mechanical disintegration, as in a rod mill, in the presence of retained liquor of substantial causticity.

In the treatment of wood it is found that very satisfactory results may be secured by adding controlled and proportionate amounts of wood chips and caustic liquor directly to a rod mill where the chips are mechanically disintegrated in the presence of caustic liquor. The amounts of caustic liquor added is preferably controlled so that the liquor is absorbed by the wood chips during the disintegration. It is found that if the partially disintegrated chips are allowed to stand in the presence of their absorbed alkaline liquor for a period of time, such as for about 12 to 24 hours, they defiber more readily than if they are run directly through the apparatus. Very satisfactory results may be secured in this manner by using two or more rod mills in series. For example, the wood chips admixed with a controlled amount of alkaline liquor, preferably at a consistency materially above 10%, may be passed through a first rod mill where the chips are partially disentegrated and liquor absorbed in the chips. These chips with the absorbed alkaline liquor are then retained in storage for about 12 to 24 hours; additional liquor is then added to prevent the wadding up of the pulped material and to facilitate the complete disintegration, and the material at lower consistency, preferably at about 10% or under, is then passed through a second rod mill.

The alkaline liquor, either added in the steeper or added directly to the raw material entering the rod mill, may be either hot or cold. It is found that the time of treatment and the temperature of the treatment are inter-dependent, the hotter the liquor the less time required for the proper softening of the raw material. Very suitable results have been obtained by maintaining the liquor at a temperature slightly below the boiling point, about 90° C., in order to prevent objectionable steam formation which would escape freely into the building containing the open steeping tanks or open-ended rod mills. By this method the yield of finished stock is usually in excess of 70% of the original raw materials, and yields as high as 90% have been obtained.

Referring to Figs. 1 and 2 in the drawings, apparatus constituting a preferred embodiment for the treatment of straw, fibrous grasses and the like is illustrated. Bales of straw as indicated at 10 are placed upon an endless conveyor 11 which is adapted to be driven at a suitable speed by any suitable mechanism not illustrated. After being placed upon the conveyor belt 11 the bales 10 are broken open before being fed into the duster mechanism 13. The duster mechanism may be of the conventional type used in the industry for dusting old paper stock and the like, and needs no further illustration. Toothed rolls 14 are provided for pulling the straw apart and feeding it into the duster and for suitably sub-dividing it. The loose straw feeds through the discharge chute 15 directly into the feeding hopper 16 of the steeping tank 17. A spray pipe 18 suitably perforated on the under side is adapted to spray caustic liquor upon the straw as it feeds into the hopper 16 to thereby wilt the straw and facilitate its passage into the tank 17. The spray pipe 18 is connected by pipe 19 with a suitable source (not shown) of fresh caustic liquor which may come directly from a recovery plant for the spent liquor.

Any suitable construction of steeping tank, such as that disclosed in the co-pending application of John Traquair, Serial No. 160,096, filed January 10, 1927, issued as Patent No. 1,843,464, dated Feb. 2, 1932 may be used. As shown, the tank comprises an elongated preferably cylindrical casing 20 which is normally kept substantially filled with steeping liquor. Passing through the inlet end of the tank is a shaft 23 which carries within the tank suitable means for forcing the steeping material toward the outlet end of the steeping tank, this means being illustrated as a helical screw 24. The opposite end of the shaft 23 may be supported by a bearing 25 carried by a cross-bar or beam fastened to the end of the tank. The shaft 23 carries on the exterior of the tank means shown as a gear 26 which may be driven from any suitable source of power (not shown) in order to rotate the screw 24.

The outlet end of the steeping tank 17 as indicated at 27 is open to permit the free flow of steeping material through this end. A discharge chamber 28 is formed at this end of the tank by an extension of the casing. Supported on a roll 29 which is journaled in opposite sides of the chamber 28 and running thereover is an endless elevator indicated at 30. The elevator is provided with a plurality of wire buckets 31, each of which is preferably constructed somewhat in the form of a pitchfork having a plurality of curved prongs. A suitable supporting and enclosing structure 32 is provided for the upper end of the elevator and a second roll 33 journaled in this supporting structure carries the elevator at this end. Either of the rolls 33 or 29 may be positively driven by any suitable mechanism (not shown) in order to elevate the steeped material from the steeping tank 17 and discharge it through the chute 35. As the buckets or forks conveying the steeped straw pass above the liquid level, the liquor contained therein drains rapidly back into the steeping tank. The height of the elevator is so proportioned that a large percentage of the steeping liquor is thus returned to the steeping tank, the straw passing through the chute 35 preferably carrying from 5 to 6 parts of liquor to one part of straw.

The steeping liquor is preferably maintained hot, but below the boiling point, although satisfactory results may be obtained by using cold liquor and increasing the time of steeping. Very suitable results have been obtained by maintaining the steeping liquor at a temperature of about 90 or 95° C. and so proportioning the speed of the screw conveyor 24 that the straw is allowed to steep for approximately one-half to one hour. It is found that quite dilute steeping liquor functions satisfactorily, and satisfactory results are obtained by steeping in as dilute liquor as 1% NaOH. The concentration may be varied between 1% and 6% with satisfactory results, but increasing the concentration above 6% does not appear to give advantages sufficient to make the increased concentration desirable.

Any suitable means may be employed in maintaining the steeping liquor at the proper temperature where hot liquor is used, such as the construction disclosed in applicant's co-pending application referred to above. As shown, a false perforated bottom 36 is preferably provided for the steeping tank, the bottom of the shell 20 of the steeping tank being inclined below this false bottom from the ends of the tank downwardly toward the center as indicated at 37 to provide a liquor removing chamber 38. Liquor may be removed from this chamber through a pipe 39 and passed through suitable filtering and heating apparatus (not shown) and then returned to the steeping tank to maintain the temperature. Further, the liquor introduced through the pipe 18 may be heated to assist in maintaining the temperature. A large excess of liquor is preferably used in the steeper so that the straw will be floated along with the liquor. Very satisfactory results are obtained when as much as twenty parts of liquor are used to one part of straw, at which proportion the straw moves easily. The causticity of the liquor is so controlled and the time of treatment and the amount of fibrous material added is so coordinated therewith that the straw being removed from the steeping tank retains a portion of the liquor as above described, which liquor still has substantial causticity, preferably around 30% of the original active caustic content or over. That is to say,—less than 70% of fresh caustic added has reacted with the fibrous material so that the liquor retained in the removed straw still contains about 30% or over of active caustic content. With this method, the total caustic consumption is generally maintained as low as 5% to 10% on the dry weight of the fibrous material, the major portion of which reaction takes place rapidly within the steeper. Very satisfactory results are obtained by adding a sufficient excess of active caustic liquor to insure that the liquor retained in the steeped material has substantial causticity of the order above mentioned.

The steeped fibrous material with retained caustic liquor is introduced into the inlet end 40 of a rod mill 41. The rod mill may be of any suitable conventional construction. As illustrated, the mill is of the Hardinge type having a cylindrical lined casing 42 provided with conical ends 43 and an extended hollow trunnion 44 through which the material is introduced, and an outlet or discharge trunnion 45. The mill is supported in suitable bearings 46 carried by the standards 47, the bearings receiving and rotatably supporting the hollow trunnions. Within the casing 42 are a plurality of metal rods 48. On the exterior of the shell 42 is an annular ring gear 49 which is driven from any suitable source of power (not shown) in order to rotate the casing 42. As the casing rotates, the tumbling and cascading of the rods 48 within the casing effects a pounding, rubbing and shredding treatment of the fibrous material passing into the rod mill which effectively disintegrates or defibers this material. It is found that the uncooked fibrous material in the presence of the caustic liquor, or in a fairly alkaline condition, possesses characteristics which permit effective mechanical disintegration without the consumption of excessive power. Satisfactory results are obtained by controlling the feed to the rod mill so that an effective time of treatment of from ten to thirty minutes is secured therein.

A rod mill of this type is generally provided with a plurality of discharge ports 50 positioned in the conical wall of the discharge end of the mill, these ports being provided with removable covers. The mill is also provided with a plurality of peripheral discharge ports 51 also provided with removable covers, adjacent the discharge end. The disintegrated pulp may therefore be discharged through the hollow trunnion 45 or through the ports 50 or 51, or through several of these sets of ports, depending upon the charatcer of the material being treated. When pulp of high consistency, such that it will not readily flow through the mill is being treated, the peripheral discharge ports 51 or the ports 50 in the conical end wall are generally used. When pulp of lower consistency such that it will flow is being treated, the ports 50 and 51 are generally closed by the removable covers and the disintegrated material is discharged through the hollow trunnion 45.

As shown, the material discharged from the rod mill is passed either through the chute 55 or the discharge opening 56 into a pit or chamber 57 forming a stock chest. Passing transversely through the chamber 57 is a shaft 58, which extends through stuffing boxes to the exterior of the pit and is provided with exterior bearings 59 and 60. Fastened to the shaft 58 within the chest 57 are a plurality of agitators or mixing arms 61, shown to be three in number. These agitators 61 may be of any suitable construction, and are provided to stir up and mix the stock within the chest 57. As shown each agitator comprises two diametrically opposed blades, the blades of adjacent agitators being disposed at different angles. The shaft 58 is provided with a pulley or gear 62 which may be driven from any suitable source of power.

The bottom of the chest 57 is provided with a discharge pipe 65 within which is connected a pump 66, illustrated as of the centrifugal type, driven by an electric motor 67. The discharge end of the pipe 65 feeds the stock into the central compartment of a conventional head box 68 which is provided with an overflow partition 69 by which the excess of stock pumped thereto may be discharged into the return pipe 70 and fed back into the chest 57. The head box 68 is also provided with a second partition 71 having a movable gate 72 with a controlled opening or weir, so that a controlled amount of the stock may be discharged through a chute 73 into a conventional mixing box 74. The mixing box 74 is provided with a plurality of staggered baffles indicated at 75 to thoroughly mix the stock passing therethrough. The mixing box 74 discharges into a pipe 76 which feeds into an open tank 77.

Rotatably mounted and dipping in the stock within the tank 77 is a rotary vacuum filter 80, which filter may be of any conventional construction, for example of the type known commercially as the Oliver filter, such filters being well known in the art and so not particularly illustrated herein. This filter 80 comprises a perforated rotary screen divided into compartments of definite suction areas. The screen dips into the stock within the tank 77, the suction causing the fibrous material to accumulate on the surface of the screen. As the screen rotates carrying the filtered defibered material above the liquid level within the tank, sprays of water or other washing liquid are directed from suitably disposed spray pipes 81 upon the stock on the filter. The material is thus washed practically free of the treating and steeping liquor, the liquor being at this time substantially spent of its active caustic content and so may be termed "black liquor". As the filter continues to rotate, the material which has thus been washed arrives at an area which is not subject to suction, and at this point a flexible scraper member (not shown) carried by the side of the tank 77 scrapes this material from the filter, causing it with the assistance of suitably directed sprays to slide down the scraper member over the edge of the tank 77 into a chute 82 which discharges at 83 into a stock chest 84 provided with an agitating shaft 85 having agitators 86 and a driving pulley or gear 87.

As the fibrous material accumulates upon the screen of the rotary vacuum filter 80, the black liquor is sucked through into the interior of the filter, and then the remaining black liquor in the fibrous material is washed out by the sprays directed upon the fibrous material, so that the black liquor is substantially all removed from the fibrous stock. Preferably controlled amounts of wash-water are added to the fibrous stock on the filter, so that the black liquor is substantially all washed out, the washing water taking its place, but so that unnecessary dilution of the black liquor is avoided. The black liquor sucked from the fibrous material to the interior of the filter 80 passes by the pipe 90 to the vacuum tank 91 provided in connection with the vacuum filter. This vacuum tank 91 is also of conventional construction, such as is used in connection with rotary vacuum filters of this character, the vacuum tank being provided with a vacuum pump 92 for producing the necessary suction within the rotary vacuum filter. For withdrawing the black liquor from the vacuum tank 91 against suction existing therein, a pipe 93 is tapped into the bottom of the vacuum tank 91, and a centrifugal pump 94 operated by a motor 95 is positioned within the pipe 93. The pump 94 discharges into a pipe 96 which in turn discharges into the central compartment of a second head box 98.

The head box 98 is provided with an overflow partition 99 whereby the excess of black liquor is discharged into a pipe 100, which in turn discharges into the stock chest 57. The black liquor thus removed from the fibrous stock in the rotary vacuum filter is returned to the chest 57 to make down or dilute the stock discharged into the chest from the rod mill, the stock being made down at this point to a consistency such that it will readily flow and can be pumped, preferably about 3% to 5%. The stock is further made down before it passes to the rotary vacuum filter by means of water or dilution liquor added at the head box 68 from a pipe 102, so that the consistency of stock passed to the Oliver filter is about 1%.

The head box 98 is also provided with a second partition 105 having a sliding gate 106 with a controlled opening or weir. In this manner controlled amounts of the black liquor pumped to the head box 98 are discharged into the pipe 107 which leads to a recovery plant (not shown) which may be of entirely conventional form such as used in the recovery of black liquor formed in the digesters in the manufacture of soda pulp. The steps in the recovery or regeneration of the liquor are well known, and consist essentially of evaporation of the liquor, burning of the residue to black ash, the lixiviation of the black ash, and the causticization of the extracted liquor. From the recovery plant, fresh caustic liquor may be supplied through a conventional heater (not shown) to the spray pipe 19. Thus a self-contained process for the manufacture of paper-forming stock from raw fibrous materials is provided, in which the chemicals used can be recovered so that there is little loss of chemicals in the process, and stream pollution is entirely avoided.

The stock chest 84 is provided with an outlet pipe 110 through which the stock is adapted to be pumped by a centrifugal pump 111 driven by a motor 112 through pipe 113 to a gravity feed head box 114. The head box 114 is provided with a discharge pipe 115 which feeds into the inlet end 116 of a conventional refiner, illustrated as a Jordan 117. The Jordan may be of entirely conventional construction and so is not more particularly illustrated herein, and comprises a conical or tapered plug having exterior knives driven by a motor 120 through a flexible coupling 121, and a surrounding similarly shaped conical casing 122 having interior knives cooperating with the exterior knives on the plug. The pulped fibrous material passing through the Jordan is "brushed out", the fibers being effectively separated and the pulp having its character controlled so that it is in a satisfactory condition to be passed to a forming machine where it is made into board, or wrapping paper, or the like. The Jordan is provided with a hand control 123 whereby the inner plug may be regulated with reference to the stationary casing 122 to control the refining action and therefore control the final characteristics of the pulp. In this manner, satisfactory pulp for formation into a good grade of board or wrapping paper may be prepared directly by mechanical disintegration without cooking. The pulp is discharged from the Jordan through a pipe 124 which leads the refined pulp to a suitable stock chest or head box of the paper-forming machine (not shown).

In Fig. 3 is illustrated a preferred embodiment of apparatus adapted particularly for the treatment of wood. A hog or chip breaker is illustrated at 130, this being of entirely conventional construction as used in the industry for breaking up logs or pieces of wood into chips of a size such as is used for boiler fuel for example. The chips are discharged through a chute 131 into a chip storage 132, which may be of silo construction comprising a cylindrical container having an open upper end 133 and a lower inclined or conical end 134 with a discharge opening 135 feeding into a conveyor 136.

The conveyor 136 may be of any suitable construction, being illustrated herein as a screw conveyor having a single shaft 138 driven from a pulley or gear 139 and carrying a helical screw 140. Intermediate the intake and discharge of the conveyor 136 is positioned an alkaline liquor supply pipe 142 controlled by a valve 143. The discharge end of the conveyor 136 is positioned within the hollow inlet trunnion 145 of a rod mill 41′, similar to the rod mill above described.

The speed of the screw conveyor 140 and the supply of caustic liquor controlled by the valve 143 are so coordinated that the raw chips and the caustic liquor are admixed in controlled and proportionate amounts prior to the introduction of the mixed mass into the rod mill 41′. It is found preferable from the standpoint of economy and satisfactory operation to control the addition of caustic liquor to an amount which can be absorbed by the disintegrated material during the rod milling. Very satisfactory results have been secured where 1½ to 2 parts of NaOH liquor to one part of chips on the dry weight of the wood are supplied in admixed condition to the rod mill. Either hot or cold alkaline liquor may be supplied, but preferably heated caustic liquor is added to thereby reduce the time of rod-milling treatment to a minimum. Very satisfactory results have been secured where caustic soda at a temperature of about 95° C. has been added to the raw chips, and the admixed materials subjected to treatment in the rod mill for about ten to twenty minutes. Where the liquor is added directly to the chips entering the rod mill without steeping, a more concentrated liquor than that used in the steeper is preferably used. Very satisfactory results are secured with a liquor containing from about 3% NaOH to 10% NaOH, although more dilute liquor may be used with an increase in the time of treatment.

The partially disintegrated chips and admixed liquor, which at this time still retains a substantial amount of causticity, are discharged through the discharge trunnion 146 into an elevator 147 which may be of similar construction to that above described, except that where chips are being handled ordinary perforated buckets 148 are provided instead of the pitchfork type of buckets. Where chips at high consistency are being treated, the disintegrated material is usually discharged through peripheral ports 51′ onto a chute 149 which in turn feeds into the elevator 147. The elevator 147 is arranged to discharge through chute 150 into a chip storage 151 which may be of silo construction similar to the chip storage 132. The size and capacity of the chip storage 151 is so proportioned to plant operation, that the chips with absorbed caustic liquor may be allowed to stand therein for a substantial period of time such as about 12 to 24 hours. This storage period is thus accommodated during the continuous operation of the plant and as the chips pass from the upper end to the lower end of the chip storage 151. It is found that by allowing the disintegrated chips with absorbed caustic liquor to stand for this period, a further reaction between the liquor and the fibrous material takes place with additional softening of the material, and it is more readily and completely disintegrated by a second disintegrating treatment.

The fibrous material with its absorbed liquor is discharged through the screw conveyor 155 into a second rod mill 156, similar to the rod mill 41′. At this point the fibrous material is preferably made down to a lower consistency in order to prevent the wadding up of the pulp and to provide for a more effective disintegration and hydration of the fibers. For this purpose a head box 98′ similar in construction to that previously described is provided. Black liquor removed from previously treated stock by a rotary vacuum filter as above described is introduced through pipe 96′ into the central compartment of the head box 98′, and an overflow partition 99′ is provided therein so that controlled amounts of liquor may be added through pipe 157 into the screw conveyor 155 to make down the pulp passing into the rod mill 156. Very satisfactory results have been secured where the pulp is made down to about 10% consistency or under, and the mixed mass rod milled for about ten to twenty minutes.

The head box 98′ is also provided with a second partition 105′ controlled by a sliding gate 106′ having an overflow opening or weir through which controlled amounts of black liquor may pass into a pipe 107′ leading to recovery. The pulped fibrous material is discharged from the rod mill 156 into chute 160 which empties into a stock chest 57′. At this point, the stock is further made down to a consistency such that it will flow, and is then pumped to a rotary vacuum filter where it is filtered and washed, and is then further refined in the manner above described in connection with Figs. 1 and 2, the remainder of the apparatus being similar to that shown therein and so not illustrated in this figure.

In Fig. 4 is disclosed a somewhat modified form of apparatus particularly adapted for the treatment of wood. A chip storage 132′′ fed by a chip breaker (not shown) supplies the chips to a conveyor 136′′, and a pipe 142′′ controlled by a valve 143′′ supplies a controlled and proportionate quantity of alkaline liquor. The conveyor discharges the mixed mass into the inlet or feeding hopper 170 of a steeping tank 17'' similar in construction and operation to that described in connection with Fig. 1. The chips after steeping and softening are removed by the bucket elevator 147'', the chips draining rapidly to about 1½ to 2 parts of liquor to one of chips. The chips with absorbed liquor of substantial causticity are discharged into a chip storage 172 which is also of the silo construction having an open upper end and an inclined lower end feeding into a conveyor 173 discharging into a rod mill 41''. The chip storage 172 is provided between the steeper and the rod mill in order to permit the steeper and rod mill to operate at varying rates and to give flexibility to the operation. A pipe 174 controlled by a valve 175 is provided, so that controlled quantities of liquor may be introduced into the conveyor 173 to vary the consistency of the material fed to the rod mill 41''. Generally, where the chips have been subjected to an initial steeping the consistency is preferably made down to about 10% or under before the mass is introduced into the rod mill 41'', and a single rod-milling treatment is ordinarily satisfactory. However, if desired, the disintegrated mass discharged from the rod mill 41'' may be fed to a storage and from there discharged into a second rod mill as disclosed in Fig. 3. The remainder of the process, including filtering, washing and refining, is the same as that described above and so is not further illustrated herein.

Instead of filtering and removing the alkaline liquor from the disentegrated pulp prior to refining, the mass discharged from the rod mill may be run directly into the refiner, such as a Jordan, so that it is refined when in an alkaline condition. This gives somewhat higher strength values under certain conditions of treatment and with certain types of pulp. Where rapid penetration of alkaline liquor into the fibrous material is desired, very satisfactory results are secured by passing the dry raw material, such as the chips, into a disintegrating mill, such as a rod mill, which serves to crush and flatten the chips, and render them more porous so that a rapid absorption of alkaline liquor results.

Such a disintegrator may be substituted for the chip breaker 130 in the apparatus disclosed in Fig. 3, for example. While caustic soda is described herein as the preferred alkaline liquor, it is to be understood that other alkaline liquors may be used, such as potassium hydroxide, sodium carbonate, and the like.

The pulp produced by this method and the apparatus disclosed is found to be highly superior to the usual straw pulp made with a lime cook, for example, and board manufactured from the pulp in accordance with this method is found to be more than twice as strong as the conventional strawboard.

While the method herein described, and the form of apparatus for carrying this method into effect, constitute preferred embodiments of the invention, it is to be understood that the invention is not limited to this precise method and form of apparatus, and that changes may be made in either without departing from the scope of the invention which is defined in the appended claims.

What is claimed is:

1. In the preparation of paper-forming stock, the method which comprises introducing unpulped fibrous material into a mechanical disintegrator, simultaneously introducing an alkaline liquor into said mechanical disintegrator, passing the fibrous material through said disintegrator while subjecting it to pounding treatment of impact elements to facilitate impregnation of the fibrous material with the alkaline liquor, discharging the impregnated fibrous material from the disintegrator as fresh material is being fed thereto, and then subjecting the impregnated fibrous material to further mechanical disintegration in the presence of absorbed alkaline liquor.

2. In the preparation of paper-forming stock, the method which comprises introducing raw uncooked fibrous material into a mechanical disintegrator, simultaneously introducing an alkaline liquor into said mechanical disintegrator, passing the fibrous material through said disintegrator while subjecting it to pounding treatment of impact elements to facilitate impregnation of the fibrous material with the alkaline liquor, discharging the impregnated fibrous material from the disintegrator as fresh material is being fed thereto, and then subjecting the impregnated fibrous material to a repetition of the pounding treatment of impact elements in the presence of absorbed alkaline liquor.

3. In the preparation of paper-forming stock, the method which comprises introducing raw wood chips which have not been previously treated with chemical to soften them into a mechanical disintegrator, simultaneously introducing an alkaline liquor into the mechanical disintegrator, passing the chips through said disintegrator while subjecting them to pounding treatment of impact elements to facilitate impregnation of the chips with the alkaline liquor, discharging the impregnated chips from the disintegrator as fresh chips are fed thereto, and then subjecting the impregnated chips to further mechanical disintegration in the presence of absorbed alkaline liquor.

4. In the preparation of paper-forming stock, the method which comprises introducing unpulped fibrous material into a mechanical disintegrator, simultaneously introducing an alkaline liquor into said mechanical disintegrator, passing the fibrous material through said disintegrator while subjecting it to pounding treatment of impact elements to facilitate impregnation of the fibrous material with the alkaline liquor, discharging the impregnated fibrous material from the disintegrator as fresh material is fed thereto, allowing the impregnated fibrous material with absorbed alkaline liquor to stand to further react and soften the fibrous material, and then subjecting the impregnated and softened fibrous material to further mechanical disintegration in the presence of absorbed alkaline liquor.

5. In the preparation of paper-forming stock from raw fibrous material, the method which comprises mechanically disintegrating subdivided fibrous material in the presence of an alkaline liquor, the fibrous material absorbing alkaline liquor during the disintegration, allowing the disintegrated fibrous material with absorbed alkaline liquor to stand to permit said liquor to further react and soften the disintegrated fibrous material, and then subjecting the fibrous material with absorbed liquor after standing to a second mechanical disintegrating treatment.

6. In the preparation of paper-forming stock from raw fibrous material, the method which comprises mechanically disintegrating subdivided

fibrous material in the presence of a controlled quantity of caustic liquor such that the liquor is substantially all absorbed by the fibrous material during the disintegration, allowing the disintegrated fibrous material and absorbed caustic liquor to stand to permit further reaction and softening of the fibrous material, adding additional liquor to the material after standing to make down to a lower consistency, and then further mechanically disintegrating the fibrous material at such lower consistency.

7. In the preparation of paper-forming stock from wood, the method which comprises subdividing the wood into chips, adding controlled quantities of caustic liquor to the chips, rod milling the chips admixed with the caustic liquor to disintegrate the chips without cooking and cause impregnation of the chips with the caustic liquor, and then subjecting the impregnated chips to further mechanical disintegrating treatment in the presence of absorbed alkaline liquor to further disintegrate the chips and reduce the same to pulp.

8. In the preparation of paper-forming stock from wood, the method which comprises subdividing wood into chips, adding controlled quantities of caustic liquor to the chips, rod milling the chips and admixed liquor to disintegrate the chips and cause absorption of liquor by the chips, allowing the disintegrated chips with absorbed caustic liquor to stand to permit further reaction and softening of the disintegrated material, and then subjecting the disintegrated material after standing to a second rod-milling treatment.

9. In the preparation of paper-forming stock from raw fibrous material which has not previously been reduced to pulp, the method which comprises subdividing the raw fibrous material, mechanically disintegrating by a pounding treatment of impact elements the subdivided fibrous material in the presence of an alkaline liquor without cooking, and then mechanically refining the disintegrated fibrous material.

10. In the preparation of paper-forming stock from raw fibrous material which has not previously been reduced to pulp, the method which comprises subdividing the raw fibrous material, rod milling the subdivided fibrous material admixed with caustic liquor of substantial causticity and at a controlled consistency to mechanically disintegrate the fibrous material without cooking, and then subjecting the disintegrated fibrous material to a mechanical refining treatment in the presence of absorbed caustic liquor.

11. In the preparation of paper-forming stock from raw fibrous material, the method which comprises steeping the raw fibrous material in an alkaline liquor of less than 10% strength under controlled conditions of temperature and pressure so as to soften the fibrous material without substantial injury to the fibers thereof, removing the steeped fibrous material from the steeping liquor, a portion of the liquor of substantial alkalinity being retained in the removed fibrous material, and then mechanically disintegrating the removed fibrous material in the presence of the retained alkaline liquor by a pounding treatment of impact elements.

12. In the preparation of paper-forming stock from raw fibrous material, the method which comprises subdividing the raw fibrous material, steeping the subdivided fibrous material in a caustic liquor maintained at substantially atmospheric pressure and below the boiling point of the liquor, removing the steeped fibrous material from the steeping liquor while the same still has substantial causticity, permitting the steeped fibrous material to drain to thereby retain controlled amounts of the caustic liquor in the removed material, and then subjecting the removed fibrous material in the presence of the retained caustic liquor and at a controlled consistency to mechanical disintegration by rod milling.

13. Apparatus of the character described, comprising in combination, means for subdividing raw fibrous material, a rod mill, means for introducing controlled and proportionate quantities of subdivided fibrous material and an alkaline liquor into said rod mill, a storage bin, and means for introducing the disintegrated fibrous material discharged from said rod mill into said storage bin, to permit the disintegrated fibrous material with absorbed alkaline liquor to stand for further reaction and softening of the fibrous material.

14. Apparatus of the character described, comprising in combination, means for subdividing raw fibrous material, a rod mill, means for introducing controlled and proportionate quantities of subdivided fibrous material and an alkaline liquor into said rod mill, a storage bin, means for introducing the disintegrated fibrous material discharged from said rod mill into said storage bin, to permit the disintegrated fibrous material with absorbed alkaline liquor to stand for further reaction and softening of the fibrous material, a second rod mill, and means for introducing the disintegrated fibrous material after standing into said second rod mill.

15. Apparatus of the character described comprising in combination, means for subdividing raw fibrous material, a rod mill, means for introducing controlled and proportionate quantities of subdivided fibrous material and an alkaline liquor into said rod mill, a storage bin, means for introducing the disintegrated fibrous material discharged from said rod mill into said storage bin, to permit the disintegrated fibrous material with absorbed akaline liquor to stand for further reaction and softening of the fibrous material, a second rod mill, means for introducing the disintegrated fibrous material after standing into said second rod mill, and means for adding additional liquor to make down the consistency of the disintegrated fibrous material introduced into said second rod mill.

16. Apparatus of the character described, comprising in combination, means for subdividing raw fibrous material, a steeping tank having a feeding end and a discharge end, means for introducing the subdivided fibrous material and caustic liquor into the feeding end of said steeping tank, means for moving the fibrous material through said tank, means for removing the steeped fibrous material from discharge end of said steeping tank and for permitting draining of the same, whereby the steeped fibrous material retains a controlled portion of the caustic liquor still having substantial causticity, a rod mill, and means for introducing the fibrous material with retained caustic liquor having substantial causticity into said rod mill.

17. Apparatus of the character described, comprising in combination, means for subdividing fibrous material, means for adding controlled quantities of alkaline liquor having substantial alkalinity thereto, a rod mill, means for introducing the subdivided fibrous material and ad-

mixed alkaline liquor into said rod mill, a Jordan, and means for introducing the disintegrated fibrous material into said Jordan.

18. In the preparation of paper-forming stock from wood, the method which comprises subdividing wood into chips, adding heated caustic liquor to the chips in a proportion such that the liquor is capable of being substantially all absorbed by the chips, rod milling the chips and admixed caustic liquor to disintegrate the chips and cause absorption of the caustic liquor by the disintegrated chips, allowing the disintegrated chips with absorbed caustic liquor to stand to permit further reaction and softening of the disintegrated chips, adding additional liquor thereto to make down to a lower consistency, and then subjecting this material at lower consistency to a second rod milling treatment.

19. In the preparation of paper-forming stock from raw fibrous material, the method which comprises introducing the raw fibrous material before it is cooked or softened into a mechanical disintegrator in a substantially dry state, subjecting the fibrous material when in such substantially dry state to a pounding treatment of impact elements to flatten and render the fibrous material more porous, then adding an alkaline liquor to the treated fibrous material, and subjecting the fibrous material in the presence of the added alkaline liquor to a defibering treatment.

20. In the preparation of paper-forming stock from raw fibrous material, the method which comprises introducing the raw fibrous material before it is cooked or softened into a mechanical disintegrator in a substantially dry state, subjecting the fibrous material when in such substantially dry state to a pounding treatment of impact elements to flatten and render the fibrous material more porous, then adding an alkaline liquor to the treated fibrous material, and then mechanically disintegrating the fibrous material by a pounding treatment of impact elements in the presence of the added alkaline liquor.

21. In the preparation of paper-forming stock, the method which comprises introducing fibrous material into a mechanical disintegrator, simultaneously introducing an alkaline liquor into the mechanical disintegrator, passing the fibrous material through the disintegrator while subjecting it to pounding treatment of impact elements to effect disintegration of the fibrous material, discharging the disintegrated fibrous material from the disintegrator as fresh material is fed thereto, removing retained alkaline liquor from the disintegrated fibrous material, and returning removed alkaline liquor to be added to a fresh supply of fibrous material being introduced into the mechanical disintegrator.

22. In the preparation of paper-forming stock from fibrous material, the method which comprises mechanically disintegrating fibrous material in the presence of a controlled quantity of alkaline liquor, adding additional liquor to the material after this initial disintegrating treatment to make down to a lower consistency, then further mechanically disintegrating the fibrous material at such lower consistency, removing retained liquor from the disintegrated material, and returning removed liquor and adding it to subsequent fibrous material to make down, to the desired lower consistency for the second disintegrating treatment.

23. In the preparation of paper-forming stock from wood chips, the method which comprises rod milling the wood chips in the presence of controlled caustic liquor such that the liquor is substantially all absorbed by the fibrous material during the rod milling treatment, allowing the rod milled chips with absorbed caustic liquor to stand to permit further reaction and softening of the chips, adding additional liquor to the mass after standing to make down to a lower consistency, then further rod milling the mass at such lower consistency to effect disintegration of the chips, removing retained liquor from the disintegrated chips, and returning removed liquor and adding it to subsequent chips to make down to the desired lower consistency for the second rod milling treatment.

24. A process of separating the fibers of fibrous vegetable material, which process comprises soaking the fibrous material in a cold caustic alkali solution, and subjecting the soaked material to treatment in a rod mill.

25. A process of separating the fibers of fibrous vegetable material, which process comprises soaking the fibrous material in a caustic alkali solution at a temperature below 100° C., and subjecting the soaked material to treatment in a rod mill.

26. In the preparation of paper forming stock from unpulped fibrous material, the method which comprises subjecting the unpulped fibrous material in the presence of a chemical liquor and at a consistency in excess of 10% to mechanical defibering by a pounding treatment of impact elements, then diluting the treated material to a consistency below 10%, and subjecting the diluted material to a further pounding treatment of impact elements.

27. In the preparation of paper forming stock from raw wood chips, the method which comprises subjecting the raw wood chips without cooking to mechanical defibering by a pounding treatment of impact elements in the presence of a chemical liquor and at a consistency in excess of 10% to cause impregnation of the chips by chemical liquor, then diluting the impregnated chips to a consistency below 10%, and subjecting the diluted material in the presence of impregnating chemical liquor to a further pounding treatment of impact elements.

28. A process of separating the fibers of fibrous material, which comprises soaking the fibrous material in a caustic alkali solution at a temperature below 100° C., and subjecting the soaked material to mechanical defibering by a pounding treatment of impact elements without grinding.

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