June 29, 1943. J. B. BEVERIDGE ET AL 2,323,194

APPARATUS FOR THE PRODUCTION OF PULP FROM CELLULOSIC MATERIAL

Filed Aug. 7, 1940 2 Sheets-Sheet 1

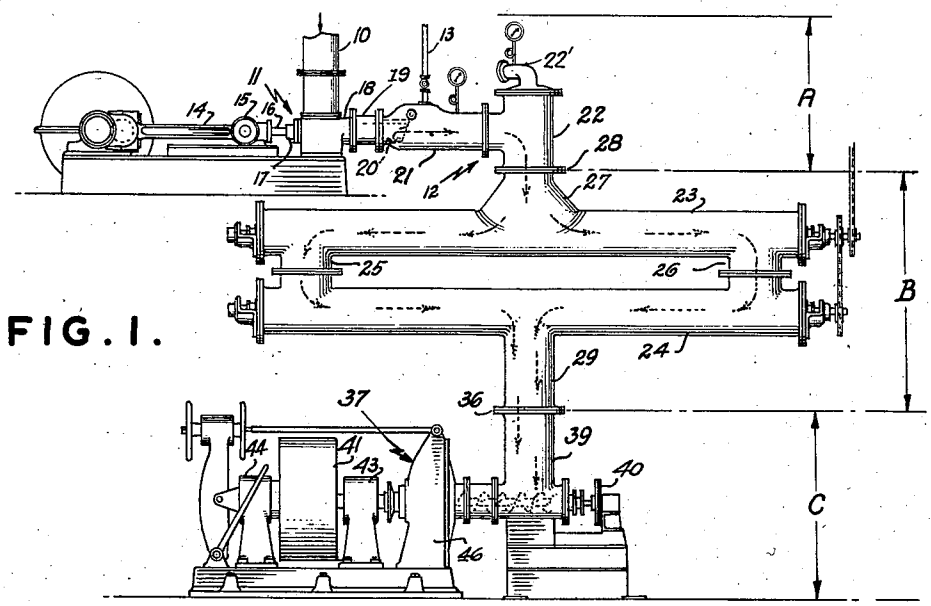


FIG. 1.

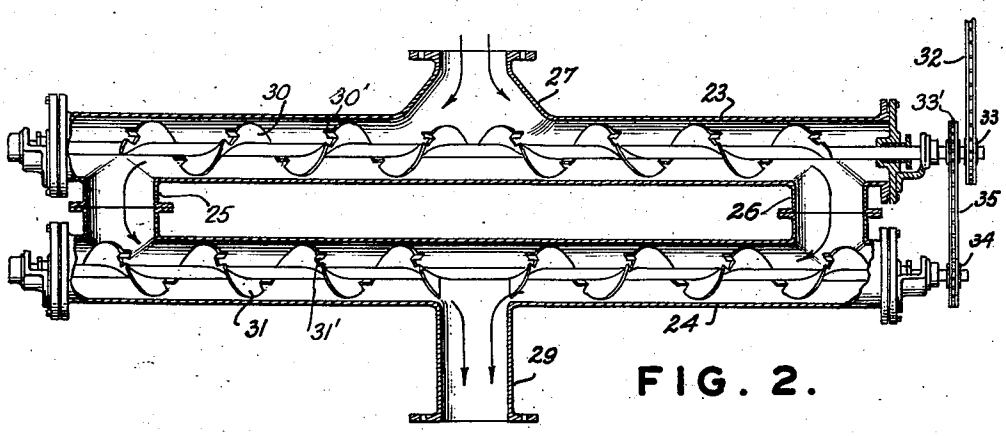
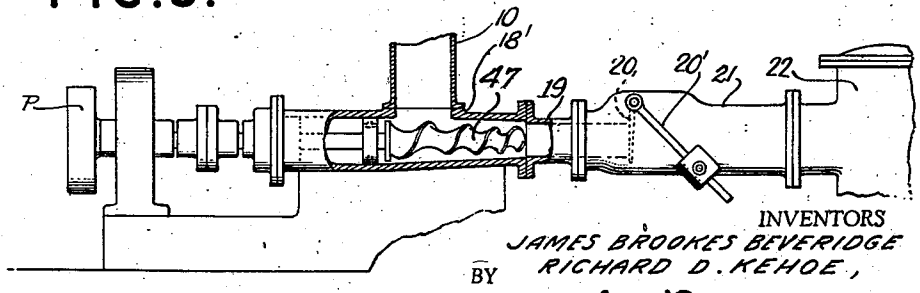


FIG. 2.

FIG. 5.



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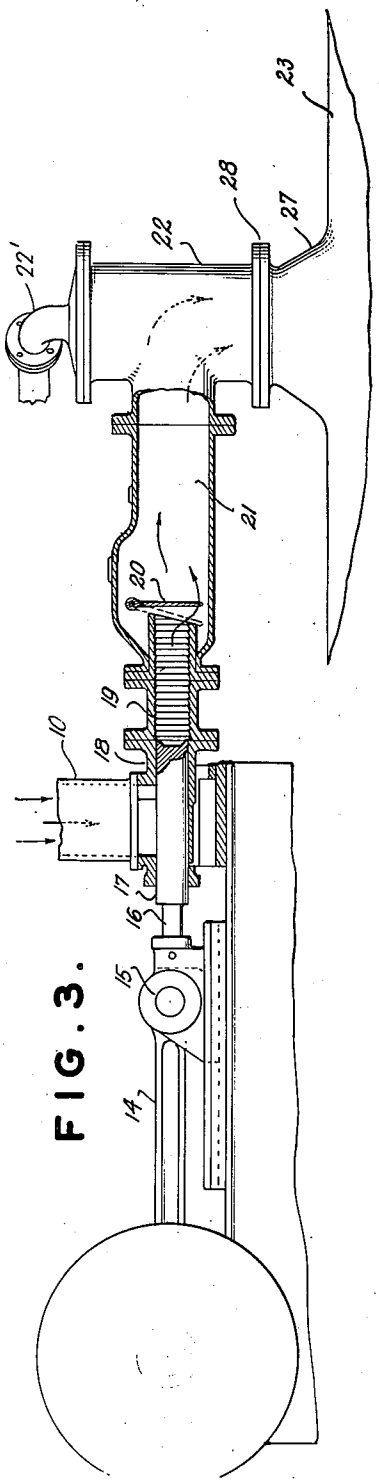


FIG. 3.

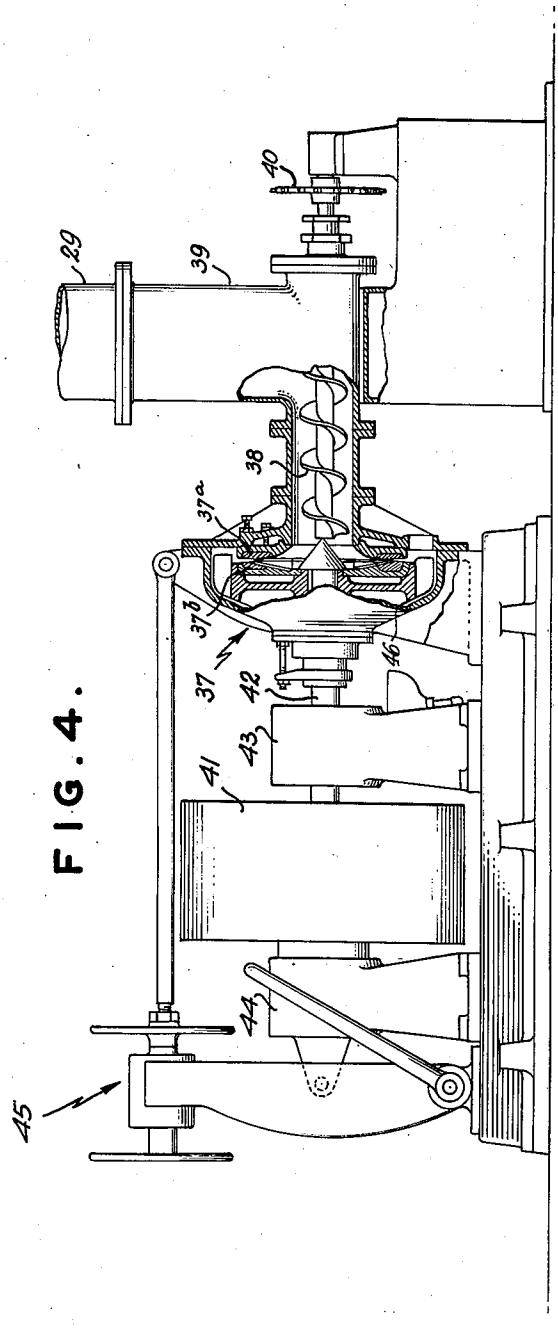


FIG. 4.

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2,323,194

APPARATUS FOR THE PRODUCTION OF PULP FROM CELLULOSIC MATERIAL

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Application August 7, 1940, Serial No. 351,670

7 Claims. (Cl. 92—6)

The invention relates to the production of pulp from cellulosic material. More particularly it relates to improvements over the process and apparatus disclosed in the U. S. patents to Asplund, No. 2,008,892 and No. 2,145,851, respectively.

In a broad sense the patented process and apparatus differ from conventional cellulose digesting or cooking steps in that a preliminary softening of the lignin in the wood chips or ligno-cellulose material, as well as a subsequent mechanical defibration step takes place in a steam atmosphere of certain temperature and pressure conditions. Moreover, this known process and apparatus are designed for and capable of absorbing material of a grade, type, and fineness, such as sawdust or the like, not ordinarily acceptable for use in the conventional cellulose digesting and cooking steps.

More in particular, ligno-cellulose material of relative dryness is subjected to an atmosphere of saturated steam in a pressure chamber for a period of time just sufficient to soften markedly the middle lamella (lignin), followed by a step of mechanical defibration whereby the material is separated into fibers also within the atmosphere of that pressure chamber. The condition of the atmosphere in this pressure chamber or system is defined substantially by a temperature range between 212° F. and 390° F., and by pressures corresponding to saturated steam of that temperature.

The apparatus or system, to carry out said process, provides a pressure chamber in which the ligno-cellulose material such as wood chips is first subjected to direct contact with the steam and then fed to a rotary refiner. The apparatus is capable of continuous operation, since the chips are introduced into the system in the form of a plug by means of a mechanical pressure-feeding device, the feed pressure forming the plug being sufficient to prevent the escape of steam through the plug inlet, while the finished or defibrated stock is discharged out of the pressure system by way of suitable valves in the discharge conduit, substantially without impairing the operating pressure and other conditions therein in the system.

In the operation of the Asplund system, it is recommended that the chips be heated substantially only until the interior of the chip has assumed the temperature of the surrounding atmosphere of saturated steam, and that a period of less than 60 seconds and on the average of 40 to 50 seconds is sufficient for the material to be brought up to the critical temperature necessary to soften the middle lamella, so that it can be separated into fibers when subjected to the disenfibering action of the refiner. The length of the period of treatment thus allowed for, is dependent upon the construction and capacity of the apparatus and hence variable only within relatively narrow limits.

Those variable factors that influence the Asplund process as practiced to meet a variety of conditions, may be said to lie in the control of temperature and pressure alone. With the use of saturated steam, each pressure value will have its corresponding temperature value. The possibilities of influencing or adjusting the operation by way of these variables may be graphically represented by a line or curve in a two-dimensional system, each point of that line or curve representing a pair of values such as a pressure value, coupled with a temperature value. The possibilities of conducting the operation may then be viewed as being limited to the dimensions of that line or curve.

According to this invention, there are added to the operation of Asplund one or more controllable factors or variables, for instance, especially the time factor which, graphically speaking, adds another dimension to the field of operating possibilities. In this manner are obtained unexpected and highly useful technical results incident to a great increase in the flexibility and adaptation of the operation, and an unexpected improvement of the fiber product. In terms of apparatus, this means the addition or interposition in a system, such as that of Asplund, of a treatment stage whereby such additional or extended control can be practiced.

The main objects of this invention are attained by introducing into such a heat-pressure system, a controlled stage or zone of detention through which the material is conveyed at a controllable rate of speed, concurrently with a controllable, preferably mild, type of mechanical stirring, and under controllable conditions of temperature, pressure and atmosphere as may be maintained in said stage or zone. For certain reasons, this zone will herein be referred to as the reaction zone or chamber, and it is interposed in the pressure system between the feeding or plug-forming end and the refiner end thereof. The variable factor of controlled speed at which the material is passed through this interposed reaction chamber, may affect the choice of the temperature and pressure factors, and consequently may help control the pre-

conditioning of the fibers prior to their entry into the refiner where, in turn, the condition of the material is liable to affect the power consumption incident to defibration.

To be precise, there are still other potential variable factors which, if superimposed upon the basic factors of pressure, temperature and time, may help to modify in a highly-sensitive and useful manner, the operation in that zone. Such additional or superimposed factors are mechanical and chemical. They lie in the intensity and type of stirring action imposed upon the material, and in certain concurrent chemical or physical action that may take place of its own account or as a secondary result of the controlled treatment in that detention zone, or which may be induced in a more or less controlled fashion by the addition of chemicals to the material being exposed to the atmosphere in that reaction zone. By utilizing all of these factors or variables, a cumulative advantage may be gained in the operating of the pressure system, and a maximum of economy, as well as a desired optimum in the qualities of the individual fibers may be thus attained, with a consequent optimum in the strength and tear of the final product.

Consequently, the invention has process and apparatus features having to do with the conditioning of the fibers prior to their entry into the rotary refiner in a pressure system of the Asplund type.

According to one feature, a controllable detention period accompanied by stirring or rubbing action is imposed upon the material in the pressure system ahead of the refiner and in addition to the heat and pressure conditions prevailing therein.

According to another feature, chemical reaction or dissolving action is added to the mechanical and thermal action during a controlled detention period. By the proper balancing of these factors with one another, the operation may be conducted with a minimum of consumption of steam, chemical, and power. A chemical, or chemicals, is introduced into the detention zone, having a solvent action on or capable of rendering soluble resins, lignin and binding matter contained in the cellulosic material being treated but especially lignin. The chemical may be organic or inorganic, or may be acid or alkaline. It may be sodium hydrate or other sodium compound, or a mixture thereof. It may be a sodium-acid sulphite, a free acid, an oxidizing or wetting agent. The chemical may be supplied to the chips in any desirable phase, namely, solid, liquid or gaseous, or in the form of vapors, either directly into the system, or the chips can be presaturated or pre-treated before being fed into the system.

For instance, to produce a white pulp or fiber approximately similar in color to unbleached sulphite pulp, it is proposed to use a sodium bisulphite solution with varying amounts of free SO_2. A magnesium or calcium base can be substituted for sodium or mixtures thereof. This solution may be injected or atomized into the system with the chips. The quantity of chemicals used, the pressure and temperature, and the length of the reaction or cooking period may be varied according to the yield and the quality of pulp required.

For instance, to produce a brown pulp or fiber approximately similar in color to unbleached kraft or soda pulp, it is proposed to use a sodium hydrate solution, with or without the addition of sodium sulphide, or other sodium compound. This solution may be injected or atomized into the system with the chips. The quantity of chemicals used, the pressure and temperature, and the length of the reaction or cooking period may be varied according to the yield and the quality of pulp required.

According to another feature, the interposed treatment stage or zone is embodied in a chamber provided with conveying mechanism by means of which the material to be treated is moved along a path of suitable length at a controllable rate of speed. More specifically, this is an elongated chamber preferably having major horizontal sections provided with a rotary screw mixing conveyor.

According to still another feature, the additional treatment stage is a structural unit complete with treating chamber and conveying mechanism therein, which, at such, can be interposed in the Asplund pressure system without substantial change thereof.

In one embodiment, the additional treatment stage is a unit comprising a pair of horizontally-extending elongated sections, one of which is disposed parallel above the other, both sections having their respective end sections interconnected by way of passage sections through which the material can drop from both ends of the upper section into the corresponding ends of the lower section. The material enters this unit by way of the intermediate portion of the upper section and leaves by way of a substantially corresponding intermediate portion of the lower section. A rotary screw conveyor in the upper section is bladed in a manner to convey the material from the intermediate portion in opposite directions to both ends thereof, from where it drops into the corresponding ends of the lower section, while a screw conveyor in the lower section, in turn, brings the material from both ends to an outlet in the intermediate part. Since the Asplund pressure system comprises a receiving chamber or receiver from which the material drops downward by way of a flanged connection into a horizontally-extending feeding screw leading into the defibrator, the present additional unit just described may be conveniently interposed in the flange connection between the receiver and the feed screw for the refiner.

It is among the practical results and advantages of the improved process and system that the period of treatment or conditioning of the material prior to its entry into the refiner, may be varied or else its passage through the treatment zone correctly and accurately timed between relatively wide limits. Such controlled variations may run, for example, for periods between 1 and 60 minutes or in fact for any period desired, as compared with the 40 to 50 seconds period specified in the Asplund patents.

As another advantage there is yielded from the treatment according to this invention and as a result of time controlled thermal chemical and mechanical treatment, a defibered product of practically individually fibrous condition. This product appears to be relatively superior to anything of its kind, particularly with respect to the flexibility or pliability of the fibers, coupled with the preservation of the full length and of all the natural strength of the fibers. In this way a finished product is obtained of a quality heretofore only obtainable by more expensive conventional methods.

Another advantage due to the more carefully

controlled treatment according to this invention appears to lie in the removal of resins, gums, and pitch from pine wood and similar woods during the heat treatment by reason of spontaneous secondary effects, namely, the solvent action of the turpentine then being freed from the material itself.

As another advantage, the present improved process and apparatus constitute a valuable and economically functioning adjunct or supplementary phase in the manufacture of chemical pulp by the soda-sulphate, sulphite and other processes. In these latter processes chips are used as a starting material.

These chips vary from 1½" to sawdust. General practice is to remove sawdust through approximately ⅜" mesh screens. Sawdust is wasted. In accepted chips there is still a considerable percentage of undersize material so that when the chips are treated in the digester during cooking process, the undersize is overcooked with the resulting loss in fiber yield. We now suggest that the mesh of the sawdust screen be increased to at least ½", thus removing all chips and sawdust which pass therethrough. The result of this operation will be that the accepted chips, when cooked, will produce more uniform and better quality of fiber. The undersize chips and sawdust that have passed through the ½" screen are treated separately by this process and the improved defibrator machine, so that a more uniform and high yield of pulp will be obtained therefrom.

As in treating wood chips, the chemical treatment dissolves the binder or deligninifies the fibers so the lower temperature that is used is less likely to injure the fibers. Thus is attained improved resiliency and flexibility of usable fiber, from what, in standard practice in the manufacture of chemical pulp, is waste.

With the improvements of this invention there is obtained economically an improved fibrous product that lends itself for a variety of uses heretofore filled by inferior products of equal or higher price. For example, the fibrous products can be used to great advantage in the manufacture of plastics and other molded products in the place of wood flour or the like.

Our invention is not limited to the production of pulp and/or fiber from wood chip and wood waste, but is applicable to the production of pulp and fiber, for example, from any cellulosic starting material, such as flax, wheat and other straws, grasses, bagasse, linters, etc.

The invention possesses other objects and features of advantage, some of which, with the foregoing, will be set forth in the following description. In the following description and in the claims, parts will be identified by specific names for convenience, but they are intended to be as generic in their application to similar parts as the art will permit. In the accompanying drawings there has been illustrated the best embodiment of the invention known to us, but such embodiment is to be regarded as typical only of many possible embodiments, and the invention is not to be limited thereto.

The novel features considered characteristic of our invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and its method of operation, together with additional objects and advantages thereof, will best be understood from the following description of a specific embodiment when read in connection with the accompanying drawings in which:

Fig. 1 is a side view showing the temperature-pressure treatment apparatus including the novel treatment chamber interposed therein.

Fig. 2 is a side view showing an enlarged longitudinal section of the treatment chamber.

Figs. 3 and 4 are enlarged partial vertical sectional views of the apparatus shown in Fig. 1 having reciprocating plunger type pressure feed mechanism at the inlet end and a rotary refiner at the outlet end of the apparatus system, the interposed novel treatment chamber being only partly shown in broken-off fashion.

Fig. 5 is a modification of the pressure feed mechanism.

The temperature-pressure treatment apparatus, to embody this invention, comprises three main component parts (see Fig. 1), namely, a pressure feed and receiving section A at the inlet end of the system, a refiner or defibrator section C at the outlet end of the system, and interposed between these two sections the novel controllable treatment section B.

Substantially loose cellulosic material is fed at the inlet end of the temperature-pressure treatment system or apparatus through chute or pipe 10 or the like to a pressure feed device 11 in which the material is compressed into so-called plugs which are then delivered through a feed inlet opening into a receiving chamber or receiver 12 connected with the pressure feed device. A supply pipe 13 for steam and for chemicals, if used, leads into the receiver 12 for heating and disintegrating the plugs of material in the receiver. The very compression of the material in the pressure feed device 11 is intended to prevent the escape of steam through the inlet end of the treatment system.

The pressure feed device 11, is of the reciprocating plunger type, comprising a crank-driven connecting rod 14 wristed at 15 to the plunger rod 16. A plunger 17 operates in a housing 18 which receives the material to be treated from the chute 10, and forces measured portions of that material through a constriction member 19 having a feed inlet opening normally closed by a check valve plate 20 suitably adjustably weighed as at 20' into the receiver 12. The receiver 12 comprises a horizontal portion 21 and a vertical portion 22 connected thereto. From the vertical portion or steam dome 22, there extends a pipe 22' that in practice extends to the refiner 37.

The apparatus up to this point is or may be substantially identical to the construction shown in the above mentioned Asplund patents to which reference is made for any further detailed description in this respect. As in the Asplund process, the woody material is treated in non-submergence.

Then follows the novel controllable treatment section B, the construction of which may take a variety of forms. The basis of its construction resides in one or more major horizontally-extending treatment sections through which the material travels along a path of suitable length under the influence of suitable mechanical conveying or stirring means.

More specifically and according to the present disclosure, the treatment section B comprises an upper main horizontal tubular section 23, and a similar lower horizontal section 24 extending parallel and substantially directly below the upper section. Both horizontal sections 23 and 24 are interconnected at their ends by way of vertical

passages 25 and 26 respectively. An inlet connection or neck 27 is provided upon the upper treatment section 23 intermediate the ends thereof, and which is flanged as at 28 to the receiver portion 22. The neck 27 widens out in a manner to form a relatively smooth transition with the upper treatment section 23. The lower treatment section 24 has a discharge neck 29 disposed intermediate the ends of that section and at a point substantially corresponding to the neck 27 in the upper section.

In passing through treatment section B, the material divides and moves in opposite directions away from the neck 27 and towards the ends of the upper treatment section 23, thence through the vertical passages 25 and 26 into the lower treatment section 24, and consequently from both ends of that section the material converges towards the discharge neck 29. According to Fig. 2 a conveyer and mixing screw 30 in the upper treatment section 23 is bladed in a manner to impel the material in opposite directions, that is, outwardly and away from the inlet 27, while a conveyer screw 31 in the lower section 24 moves the material from the ends thereof towards the outlet 29. The conveyer screws 30 and 31 are shown to be driven by a chain drive comprising a main drive chain 32 engaging a sprocket 33 on the upper conveyer screw 30, and further comprising sprockets 33' and 34 and chain 35 to transmit rotation of the upper conveyer screw 30 to the lower conveyer 31. The bent fingers 30' and 31' on the conveyers 30 and 31, respectively, are effective in agitating the material being conveyed as well as lifting particles thereof out of the mass and dropping them back again. It should be noted that the rate of speed and hence the intensity of action of the conveyer screws upon the material may be varied either by varying the speed of each conveyer screw individually or by varying them both together. Variable speed means may be provided for this purpose although not particularly shown. It is to be noted that the treatment chamber B that forms the flow-path of the material being treated increases in cross-sectional area from that of the pipe 22 to the sum of the branches of pipe section 23 and two pipes 25 and 26. That is, the cross-sectional area through which the material passes in pipe or neck 22 is expanded or enlarged to perhaps double as the oppositely-directed branches or arms of pipe 23 are encountered. In other words, the woody material or chips are provided, in the reaction chamber, with a spreading out space. If the pipe 22 were full of chips, then each arm of the reaction chamber would be only half full. This decrease of proportional content of the pipes of the reaction chamber, or this spreading-out of the material, is important. After being treated in this enlarged area or passageway afforded by the reaction chamber, the passageway in the pipe 29 is restored to initial size as it is in the pipe 22.

Treatment section C comprises elements and machinery shown in the above mentioned Asplund patents, to which reference is hereby made regarding a detailed description of the parts contained in section C.

Section C is connected to the outlet 29 of section B by flange connection 36. Mainly it comprises a rotary refiner 37 having a stationary abrading portion 37^a and a rotary abrading portion 37^b, through which the material is fed by way of a feeding screw 38 which in turn receives the material through a neck 39 from the reaction chamber or controllable treatment section B. The feeding screw 38 is driven as indicated by a sprocket 40, while the drive for the rotary portion 37^b of the refiner is indicated by a pulley 41 fixed on a shaft 42 carrying the abrading portion 37^b, the shaft in turn being carried by journal bearings 43 and 44. Numeral 45 designates a device for adjusting the operating clearance between the stationary and the rotary abrading portions of the refiner, a detailed description of which is found in the aforementioned Asplund patents.

The refiner has a housing 46 from which the refined material is discharged through a sluicing system (not shown) of automatically operated valves which are designed to permit a desired operating steam pressure to be maintained throughout the treatment system, that is to say, in the receiver of section A, in the treatment chamber of section B, and in the refiner of section C.

A modification of a feeding device for the receiver is shown in Fig. 5 where the reciprocating mechanism of Fig. 1 is replaced by a rotary feed and pressure screw 47 which forces the material or wood chips into the receiver in the form of a continuous strand.

The tapered feed screw 47 operates in a tapered casing 18' that is supplied with chips through the chute 10. The screw is rotated by any suitable means such as by a driven pulley P.

Operation

The material to be digested, such as wood chips or the like are fed through the chute 10 into the pressure feed device 11 where each plunger stroke forms a compressed and compacted plug of the material, feeding it under pressure into the receiver 12. This feeding pressure of a compacted mass of the material is sufficient to substantially prevent the steam pressure maintained in the receiver to escape by way of the feeding device. Steam of suitable characteristics, for instance, saturated steam of pressures corresponding to temperatures between 212° F. and 390° F. is admitted to the receiver through steam pipe 13, which steam pressure maintains throughout the entire treatment system and extends even into the refiner 37 where the disenfibration of the material takes place.

When a neutral sulfite or reducing chemical is added, there is then in the treatment section B steam vapor pregnant with chemicals or chemically-pregnant steam vapor. This steam seems to be readily absorbed by the chips, with the result that the fibers in the chips, being chemically saturated, are therefore protected from the action of the heat, so that they do not turn brown, as is usual with ordinary heat or alkali treatment.

When using a pressure feeding device of the type shown in Fig. 5, the material is compressed and compacted by the feeding screw 47 and enters the receiver in a continuous strand, rather than in the form of individual short plugs. In this method of feeding, like that of Fig. 1, the water and air are squeezed from the chips, with the result that the chips become so dry and absorbent that thereafter they become quickly saturated with the steam and moisture from the higher temperature atmosphere of the reaction section. When the highly-absorbent chips encounter the higher moist temperature of the reaction section, they expand into a fluffed condition.

From the receiver 12 the steam-heated material passes downwardly through the inlet neck 27 into the treatment section B where it drops into the

upper tubular portion 23. Here the mixing and conveying screw 30 conveys one-half of the material in one direction and the other half in the other direction towards the respective ends of the tubular treatment portion 23, whence the material drops through the respective passages 25 and 26 into respective end portions of the lower tubular treatment portion 24 where another mixing and conveying screw carries it to the outlet neck 29, permitting it to drop into the feeding device 38 of the refiner 37 in which latter it is subjected to the disenfibering action of the abrading surfaces 37a and 37. From the refiner the treated material is removed by sluicing it through a system of automatically operated valves not shown in the present drawings. This system of valves is designed to act as closure against the steam pressure to be maintained in the system, while permitting the removal of the disenfibered material from the treatment system.

Since chemicals or solvents may have been added in some suitable form or manner to the material in this treatment process, the discharged pulp from the refiner is washed free of chemicals or other impurities to the degree of cleanliness required. The waste chemical solution in some cases can be recovered and re-used. The pulp is then screened when necessary to the desired cleanliness.

The pressure of the feeding device 11 or feed screw 47 respectively has the effect of reducing the water content of the chip, so that no excess amount, say over 60% water, is contained in the chips fed into steam atmosphere of the receiver 12. The moisture content can be increased as it passes through the system until they reach the refiner when the moisture can run as high as 80%.

The steamheated reaction chamber of the treatment section B is preferably of substantial horizontal extent, with its length selected with a view to controlling the length of time of passage of chips therethrough and thus the time that they are exposed to reaction in the chamber. This time interval will differ with different woods, and with different chemicals used, but in general we prefer a reaction time interval of at least two minutes, that may run even as long as sixty minutes.

The regulatable mechanical conveying and mixing mechanism in the reaction chamber 23 and 24 permits of regulating the flow of the material through the chamber so that the chemical and thermal action will be uniform and complete.

The extent or length of the flow path through the heated reaction chamber 23 and 24 coupled with the impelling and mixing mechanism are made use of to control the duration of the treatment of the material in the section B. It will be understood that by adjusting the speed of the conveying and mixing mechanism 30 and 31 it is possible to cause a thicker flow of material to progress slowly through this treatment section or a thinner flow of material to pass faster therethrough. By the use of the double cylindrical U-shaped reaction chamber, there is obtained a long flow path while using little floor space or head room, but more important by the two-directional flow there is intended to be obtained a spreading out rearrangement of the chips passing therethrough with respect to each other. By the time the material reaches the refiner 37, the chips have been broken down into pulp. During passage of the chips through the reaction chamber, the compacting effect of the means for feeding them into the reaction chamber is overcome and they are actually uncompacted, partly by being allowed to spread out in the enlarged section of the chamber, and partly by action thereon of the screw conveyer means.

The steam causes the chips to swell and to become more porous, so that they will absorb quickly the chemicals supplied to them. This allows the chemicals to exercise their action for rendering soluble the lignin and other substance in the wood that binds the fibers of the wood together which may be referred to as delignification. The heated reaction chamber, by being elongated, provides the time factor necessary for the chemicals to do their dissolving, but the mechanical impellers in that chamber also have a beneficial function in that the chips are rubbed against each other and kneaded in a manner that stimulates the penetration of the steam and the chemicals thereinto with consequent effective dissolving of the lignin and of the binding substances present.

Even irrespective of the effect of introduced chemicals, an improved dissolving effect upon the material may be had in the novel treatment section B because of the dissolving effect of solvents developing from material or chips themselves during that treatment, such as the pine solvent action of turpentine on the resins.

At any rate, the quantity of chemicals used, the pressure and temperature, and length of the reaction or cooking period, may be varied according to the yield and quality of pulp required.

Furthermore, by the use of suitable chemicals, we find that we can use lower temperatures and therefore, lower pressures in the steamheated reaction chamber, to obtain the desired softening and purification of the cellulosic material so that less mechanical treatment is required to rub the fibers apart when fed to the refiner.

The quality of the pulp or fiber produced according to this invention can be varied from what is known to those versed in the art of pulp and paper making as semi-chemical pulp, to the standard qualities of sulphite, soda and sulphate pulps. Pulp or fiber produced by thermal and mechanical treatment alone contains a large percentage of lignin, and incrusting material, which may result in a brittle fiber, whereas if a percentage of these materials is removed, as it is by the use of this invention apparently because lignin is rendered soluble, the resulting fiber, being purer, is more flexible and can be mechanically treated to produce a stronger and more pliable finished product such as kraft liner, papers to be saturated such as roofing and flooring felts, sheathing papers, and various grades of paper and paper board.

Treatment according to this invention results in a more complete action, chemical and thermal, on the chips, with the result that the fiber produced is softer and more pliable, and that the mechanical action to reduce to fibers requires less power. A reduction in power requirement to 90 H. P. from 135 H. P., tantamount to a saving of 33.3%, is based on a steam-heat treatment of approximately 1½ to 2 minutes (which is herein termed a "long heat treatment" as compared with the short treatment time specified in the Asplund patents), and also based on a production of 10 to 15 tons of dry fiber in twenty-four hours.

The steam pressure and temperature and quantity of steam used varies according to the quality of wood used, percentage of moisture in the wood, whether or not chemicals are used, and the quality of the fiber produced. For instance, when

using Loblolly pine, the steam pressure is 165 lbs., the steam temperature 366° F., and the quantity of steam per dry ton fiber about 1500 lbs.

As compared with the fibers obtained in the "short heat treatment" specified in the Asplund patents, we have found that with the "long heat treatment" of the present invention larger percentages of wood fiber can be used because of the pliability of the fiber, and because, according to our experience, it is less woody and brash than the fibers produced according to Asplund. For wallboard, insulating board, pressed board and other paper boards manufacture this increased pliability is of a distinct advantage.

The process can be controlled to produce—

(A) A comparatively purified pulp or fiber similar to standard grades of unbleached sulphite, sulphate and soda pulps with a yield from the wood of approximately 50%.

(B) A semi-chemical (brown) pulp or fiber with a yield from the starting material from 50% to 95%, according to quality of pulp or fiber desired. For example—

(1) A semi-chemical pulp with a yield from the starting material of 70% to 80% will produce a satisfactory sheet of paper with a caliper of .009 for corrugating purposes in the manufacture of containers.

(2) A pulp or fiber with a yield from the starting material of 85% to 95% for use in the manufacture of dry felts for the manufacture of roofing and flooring.

(C) A semi-chemical (white) pulp or fiber with a yield from the starting material varying from 50% to 90%, according to quality of pulp or fiber desired.

For example—

A semi-chemical pulp with a high yield approximating in quality high yield unbleached sulphite pulp for use in the manufacture of newsprint paper and paper boards, etc.

(D) A fiber suitable as filler material for plastics.

(E) Linters or other fibers suitable for use in nitrocellulose products and rayon.

(F) Fibers from starting materials of wood or straws for use in the manufacture of insulating or hard boards.

We claim:

1. Apparatus for the treatment of cellulosic material, having a conduit extending generally downwardly in which a gaseous environment is maintainable and having a feed inlet opening, a material-supporting vapor-treatment chamber interposed in the conduit in series therewith and forming a pathway for the material, means for establishing and maintaining in the conduit and chamber super-atmospheric steam pressure and a water gasifying temperature above 212° F. for producing a hot vapor-bearing atmosphere, a supply pipe for the material, means for continually feeding material from the supply pipe into the conduit through constriction means including a device for compacting the material and plugging it in the inlet opening against substantial gas and pressure loss when compacted material is fed to and released into the conduit, said chamber having an effective cross-sectional area larger than the cross-sectional area of the constricted feed inlet opening thereto whereby material fed thereto is substantially less than sufficient to fill said chamber, means for continually imparting to the material released into the hot vapor-bearing atmosphere a forwardly progressing rolling and kneading movement at a rate of forward travel sufficient to cause material moving through the vaporous atmosphere of the partially filled chamber to spread out and become uncompacted for thereby continually exposing new surfaces to the action of said hot vapor-bearing atmosphere, a rotary refiner connected with the conduit, and means for continually moving through the refiner material that has passed through the conduit and chamber.

2. Apparatus according to claim 1, in which the treatment chamber comprises two branches arranged in series with the conduit and operating in parallel with each other and between which the material passing through the conduit divides.

3. Apparatus according to claim 1, in which said chamber comprises a pair of substantially parallel and horizontally-extending longitudinal tubular conduit sections one above the other and in communication at adjacent ends to permit the material to pass from the upper to the lower section around said ends, and in which the conveying means is arranged to move the material first in one linear direction through the upper section and then in the opposite linear direction through the lower section.

4. Apparatus according to claim 1 in which said chamber comprises a pair of substantially parallel and horizontally extending tubular conduit sections one above the other and in communication at both pairs of adjacent ends with inlet and outlet portions intermediate the upper and lower conduit sections respectively, and in which the conveying means is arranged to move the material first through the upper conduit section in opposite directions away from the inlet portion and then in opposite directions toward the outlet portion.

5. Apparatus for the treatment of cellulosic material for yielding individualized fibers therefrom, having a conduit extending generally vertically in which a gaseous environment is maintainable and having a feed inlet opening, a material-supporting vapor-treatment chamber interposed in the conduit in series therewith and forming a pathway for the material, means for establishing and maintaining in the conduit and chamber super-atmospheric steam pressure and a water-vaporizing temperature above 212° F. for producing a hot vapor-bearing atmosphere, a supply pipe for the material, means for continually feeding material from the supply pipe into the conduit through constricting means including a device for compacting and plugging the material in the inlet opening against substantial gas and pressure loss when compacted material is fed to and released in the conduit, means for continually agitating and self-rubbing the material which swells when released to the influence of the hot vapor-bearing atmosphere and impelling it while substantially non-submerged through the vapor-treatment chamber at a rate of movement sufficient to cause the material to become loosened and spread out in uncompacted and expanded condition to expose its middle lamella to the softening action of said hot vapor-bearing atmosphere, rotary mechanical defibering means connected with the conduit, and mechanical means for continually moving the material through the refiner that has passed through the conduit and chamber.

6. Apparatus for the treatment of cellulosic material for yielding individualized fibers and whose lignin content is substantially lessened, having a conduit extending generally downwardly in which a gaseous environment is maintainable

and having a feed inlet opening, a material-supporting vapor-treatment chamber interposed in the conduit in series therewith and forming a pathway for the material, means for establishing and maintaining in the conduit and chamber super-atmospheric steam pressure and a water gasifying temperature above 212° F. for producing a hot vapor-bearing atmosphere, a supply pipe for the material, means for continually feeding material from the supply pipe into the conduit through constricting means including a device for compacting the material and plugging it in the inlet opening against substantial gas and pressure loss when the material is fed to and released into the conduit, means for supplying and maintaining in the hot vapor-bearing atmosphere of the chamber a quantity of a chemical for rendering soluble ligneous content of said cellulosic material, said chamber having an effective cross-sectional area larger than the cross-sectional area of the constricted feed inlet thereto whereby material fed thereto is substntially less than sufficient to fill said chamber, means for continually imparting to material which swells when released to the influence of the hot vapor-bearing and chemical-bearing atmosphere and while substantially unsubmerged in said chamber a forwardly progressing rolling movement at a rate of forward travel sufficient to cause the swollen material moving through the vapor-bearing atmosphere of the chamber to spread out in uncompacted condition and thereby subject to the softening and dissolving action of said chemical as modified by said pressure and temperature whereby the ligneous content of the cellulosic fibers is substantially lessened, a rotary refiner connected with the conduit, and means for continually moving through the refiner material that has passed along the conduit and chamber.

7. Apparatus for the treatment of cellulosic fibrous material for yielding individualized fibers therefrom, having a conduit extending generally vertically in which a gaseous environment is maintainable and having a feed inlet opening, said conduit including a material-supporting section incorporated in a vapor treatment chamber interposed in the conduit in series therewith and forming a pathway for the material, means for establishing and maintaining in the conduit and chamber super-atmospheric steam pressure and a water-vaporizing temperature above 212° F. for producing a hot vapor-bearing atmosphere, a supply pipe for the material, means for continually feeding material from the supply pipe into the conduit through constricting means including a device for compacting and plugging the material in the inlet opening against substantial gas and pressure loss when compacted material is fed to and released in the conduit, means for continually agitating the material which swells when released to the influence of the hot vapor-bearing atmosphere and moving it while substantially non-submerged through the vapor-treatment chamber at a controlled rate of movement sufficient to cause the material to become loosened and spread out in uncompacted and expanded condition to expose its middle lamella to the softening action of said hot vapor-bearing atmosphere, said latter means including rotary screw means to control the rate of progression of the material along said material-supporting section, rotary mechanical defibering means connected with the conduit, and mechanical means for continually moving the material through the refiner that has passed through the conduit and chamber.

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