

June 28, 1960

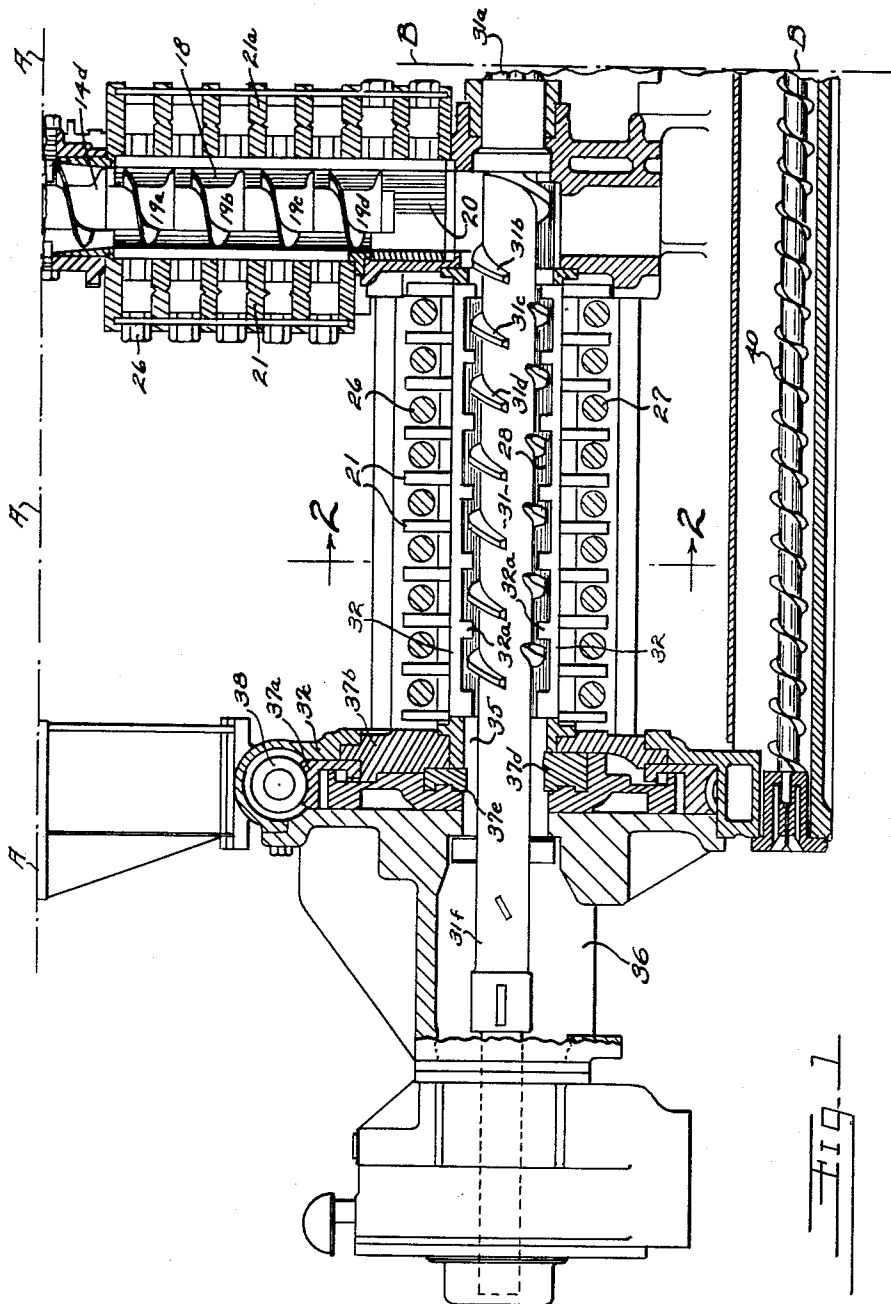
J. W. DUNNING ET AL

2,943,012

METHOD AND APPARATUS FOR FIBERIZING FIBROUS MATERIAL

Filed Dec. 1, 1955

5 Sheets-Sheet 1



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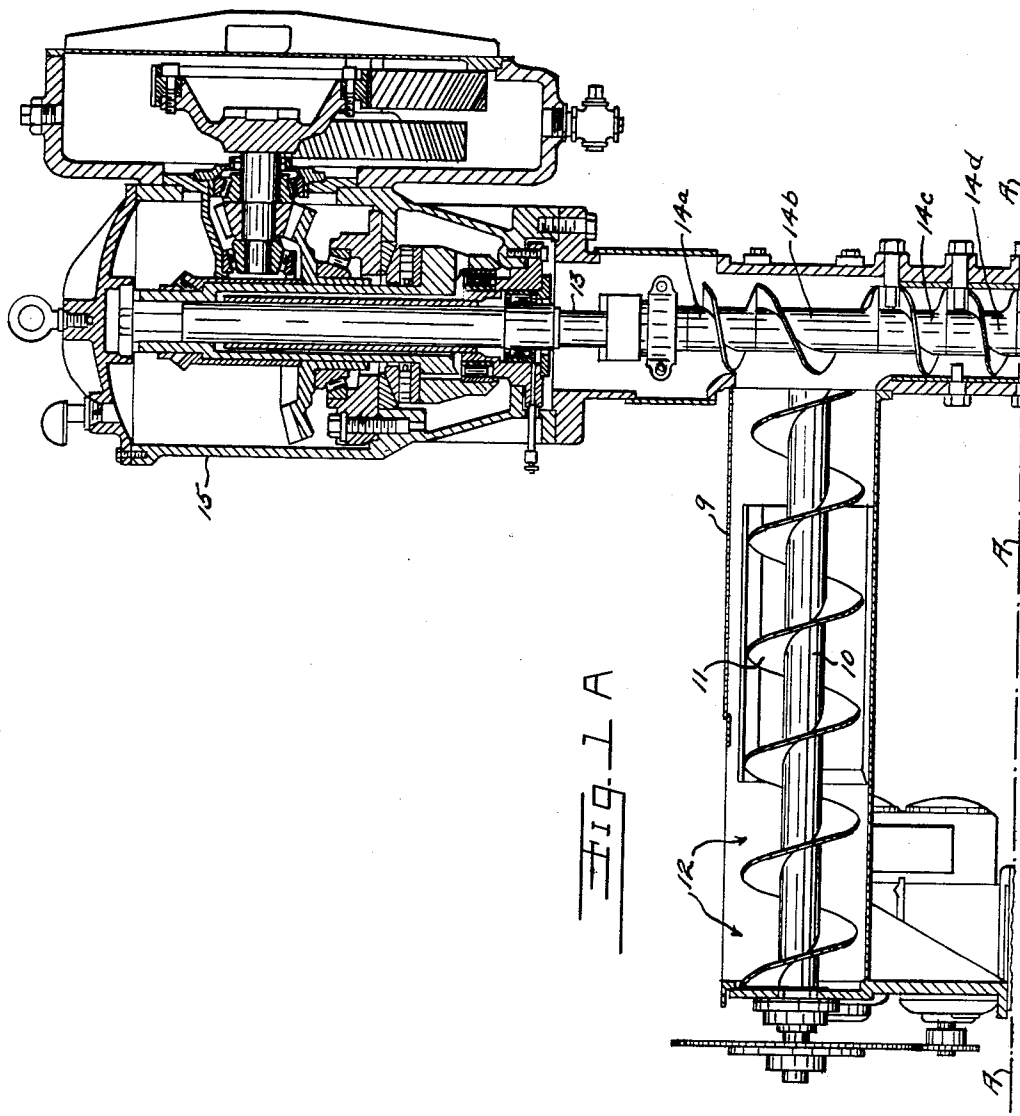
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METHOD AND APPARATUS FOR FIBERIZING FIBROUS MATERIAL

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5 Sheets-Sheet 2



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5 Sheets-Sheet 3

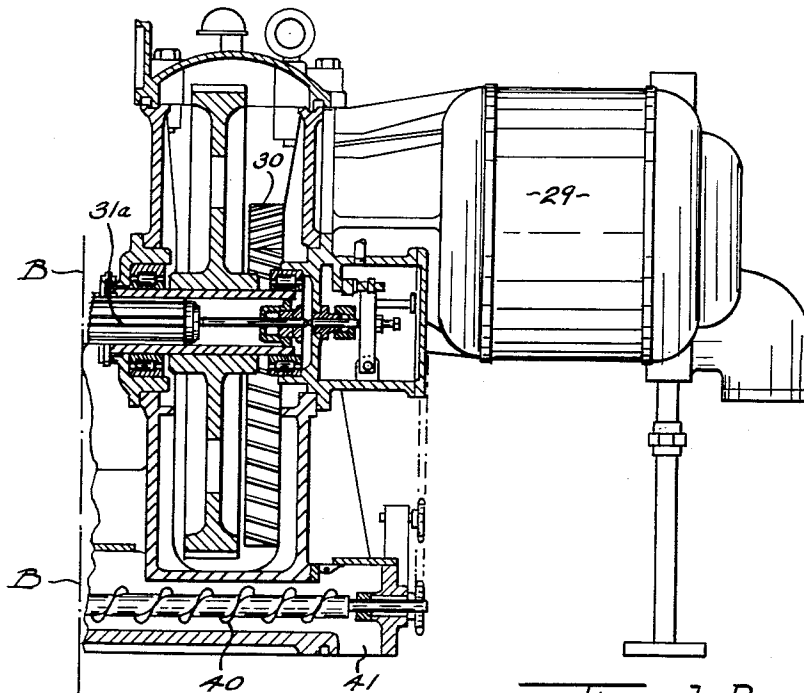


Fig. 1 B

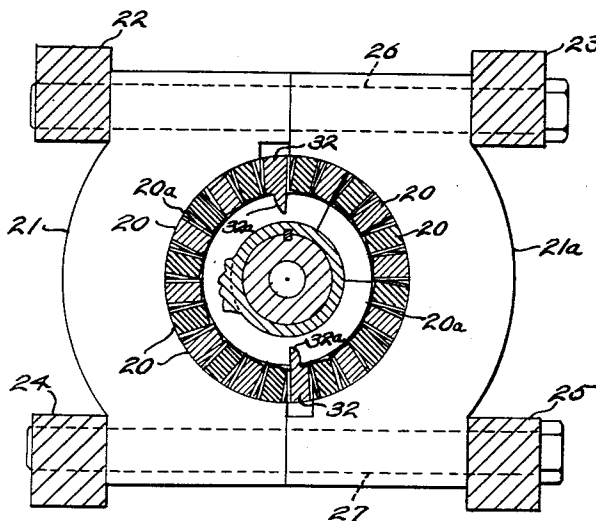


Fig. 2

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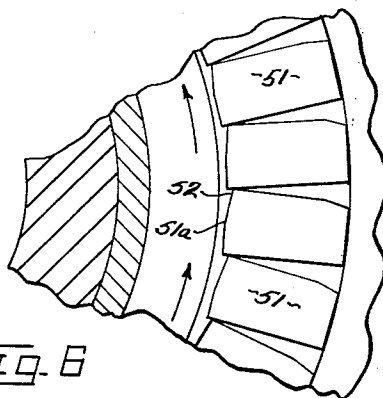
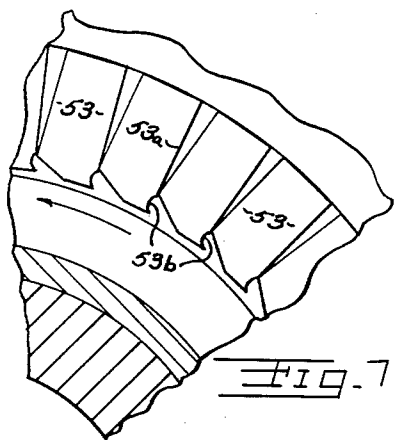
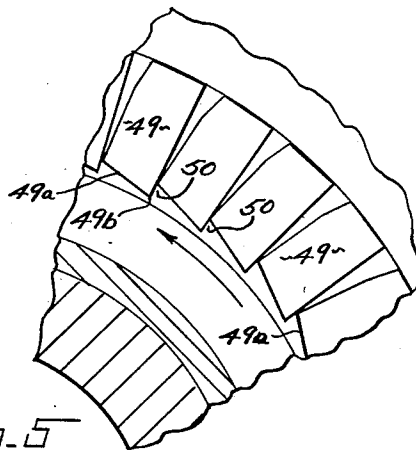
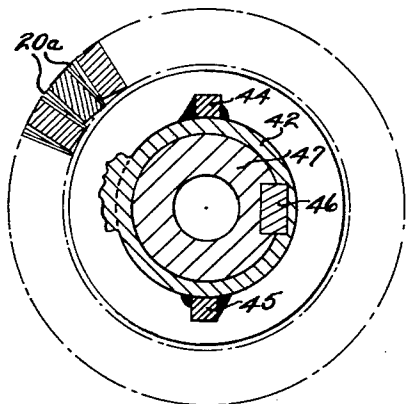
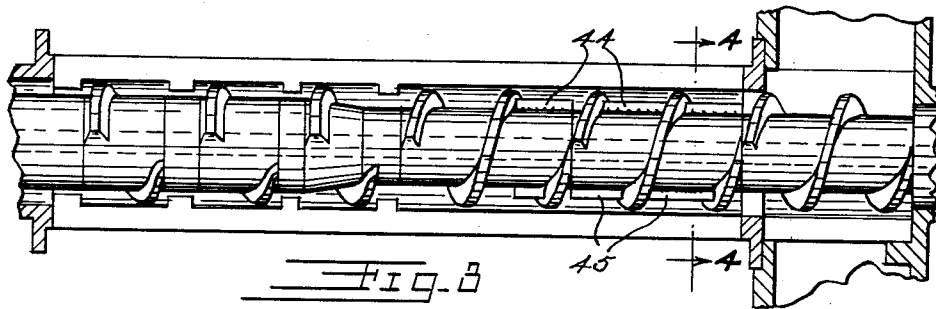
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5 Sheets-Sheet 4



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5 Sheets-Sheet 5

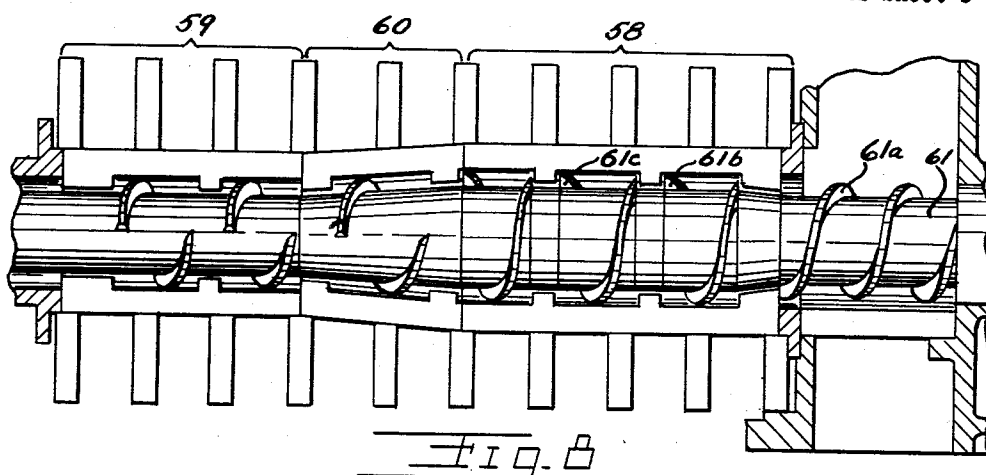


Fig. 8

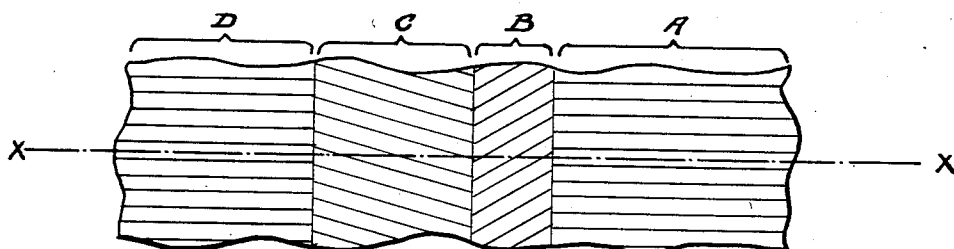


Fig. 9

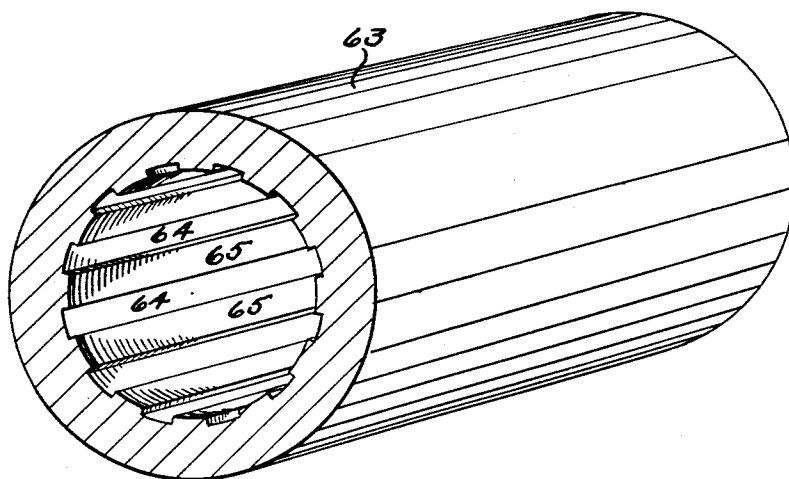


Fig. 10

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METHOD AND APPARATUS FOR FIBERIZING FIBROUS MATERIAL

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14 Claims. (Cl. 162—18)

The invention relates to methods and means for refining fibrous materials. One familiar example of such refining widely familiar to those engaged in the pulp paper industry, is the fragmentation and fiberizing of wood. The present invention will be described with specific reference to the refinement of wood. The words "refinement" or "fiberizing" when used herein will signify this treatment of wood to reduce it, wherever possible, to comminuted individual fibers, or small fiber bundles.

Other fibrous materials, natural or synthetic, may likewise be refined by the methods and means disclosed herein. Such other materials may be, for example, wheat straw, bagasse, corn stalks, cotton stalks, or the like.

Two general methods have been used in the past for the production of wood fibers, generally termed the mechanical method and the chemical method.

In one exemplification of the mechanical method logs are cut into suitable lengths, and are then brought to bear against large diameter grinding stones to reduce the wood to fibrous particles. These particles are entrained in large volumes of water, agitated, and screened in such way as to permit passage of individual fibers but intercept larger aggregates or bundles of fibers. The intercepted particles or bundles are passed to disk refiners, which comprise two parallel but spaced disks having cutting projections on their adjacent faces. The disks rotate usually in opposite directions and a sludge of the fiber bundles and water is introduced between the disks and thereby macerated and refined to a suitable consistency. Further proceedings need not be detailed here, since unnecessary for an understanding of the present invention. This initial reduction of the wood by the mechanical method requires an expenditure of energy of about 75–80 H.P. per ton days of wood.

In the chemical method wood chips are cooked or "digested" in large containers generally using a dilute aqueous solution of either calcium bisulphite, to produce "sulfite pulp," or caustic soda, to produce "soda pulp." After a suitable digestion period the chips are drained of free cooking liquor and then transmitted to the standard disk refiner for refining the mass of chips. Assuming the consumption of 4 H.P. per ton days for producing wood chips, and a further expenditure of about 16–17 H.P. per ton days in the disk refining step, the total consumption of energy by this chemical method is approximately 20–21 H.P. per ton days.

We can fiberize raw wood to suitable fiber bundles by use of the methods of this invention and at an expenditure of approximately 3 H.P. per ton days. The small fiber bundles thus produced may be refined through standard disk refiners to a finished mechanical pulp at the expenditure of an additional 50–55 H.P. per ton days. This total horsepower of 53–58 H.P. per ton days may be compared with the 75 to 80 H.P. per ton days required by the prior art in the production of ground wood pulp. When the methods of this invention are

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employed for the fiberization of chemically cooked wood chips, we can refine pulp fibers to suitable condition at an expenditure of energy of about 10 H.P. per ton days, instead of the 16 H.P. per ton days required by the prior art. Thus by using the apparatus and process of the present invention, the horsepower required by the use of this apparatus reduces the required horsepower for the production of useable pulps by 60 to 75%.

As briefly intimated hereinabove the amount of water in the slurry of digested chips, or ground fibers, as practiced by prior art methods, is relatively large, being approximately 85–90% of the total slurry. This is generally termed a 10–15% consistency mixture since the wood comprises 10–15% of the slurry. Because of the large volume of water passing through the disk refiner with the wood, much of the horsepower expended in reducing the wood fiber bundles to individual fibers is expended in moving the water itself. Therefore, in low consistency refining, as we term this method with relatively large amounts of water, a much higher horsepower consumption is required than in the high consistency method embodying our invention wherein the relative amount of water is greatly reduced, since a much larger proportion of the consumed horsepower is occupied in actual refinement of the fibers.

One object of the present invention, therefore, is to devise a method and means for defiberizing fibrous materials more efficiently than heretofore effected by prior art methods and means.

A further object of the invention is to provide methods and means as characterized in the last preceding paragraph whereby the productive capacity of fiber refining means is substantially increased.

A further object of the present invention is to provide methods and means for defiberizing fibrous materials whereby the degree of refinement can be pre-determined with substantial accuracy.

Another object of the invention is to enable us to comminute wood particles longitudinally of the fiber structure rather than perpendicular thereto, which latter is often encountered in conventional methods of refining wood pulps.

Another object of the invention is to permit a closer control of the freeness of pulps.

Another object of the invention is to permit the fiberizing of wood particles in other forms as well as in chip form, so that waste wood particles from lumber mills and elsewhere which do not lend themselves to the production of ground wood pulps by prior art practices may be reduced in size in a hammer mill or other known comminuting or shredding device prior to processing in the apparatus of this invention.

A further object of the invention is to provide methods and means for fiberizing fibrous materials wherein, as part of the fiberizing process, shredded and subsequently compressed fibrous materials containing between 30% and 80% of water are first compressed under high pressures under frictional conditions such that the temperature of the mass is raised to above the boiling point of water, and then the containing pressure is suddenly relieved, whereupon the superheated water and resultant superheated steam blow or "explode" the fibrous aggregate into its component individual fibers.

Other objects and advantages will be apparent from a study of the following description, in conjunction with the accompanying drawings, in which:

Figs. 1, 1A and 1B are, respectively, fractional portions of a unitary assembly, illustrated in this way to permit enlargement of operating structural details. Figs. 1 and 1A were split apart on the plane indicated by the line "A" in both drawings. Figs. 1 and 1B were split apart on the plane indicated by the line "B" in both

drawings. A somewhat similar machine such as would be achieved by combining Figs. 1, 1A, and 1B is shown, for example, in U.S. Patent No. 2,471,920, granted May 31, 1949, to Raymond T. Anderson.

Fig. 2 is a vertical sectional view taken on the line 2—2 of Fig. 1.

Fig. 3 is a side elevational view of another embodiment of the main press shaft, practically all of the press barrel and housing being removed.

Fig. 4 is a sectional view taken on the line 4—4 of Fig. 3, and somewhat enlarged.

Figs. 5, 6 and 7 are enlarged detail views of several embodiments of main press barrel elements.

Fig. 8 is a longitudinal axial section of a fragmentary portion of a barrel illustrating another embodiment of our invention, and

Fig. 9 is a plan view of a fragmentary portion of the inner peripheral wall of a barrel similar in some respects to that shown in Fig. 8.

Fig. 10 is a perspective view of another type of barrel. Speaking first generally, and referring to Figs. 1, 1A and 1B, we show a screw press assembly wherein a material can be processed in a number of ways by routing it therethrough while subjecting the material to heavy pressure. Since this general apparatus and routine is familiar to those skilled in the art, we will touch only briefly on the broad function and purpose of some of the main elements of the structure, after which we will refer more specifically to the novel phases of our invention.

The screw press assembly includes material feeding means comprising a horizontal, rotatable shaft 10 carrying a helical worm 11. This worm operates in a generally horizontal cylindrical housing 9 which, if desired, may be perforated for elimination of excess water, in case the pulp is highly diluted. Material is dropped in in the location of the arrows 12, and is carried from left to right (Fig. 1A) and discharged into a vertical cylindrical chute which likewise is provided with a rotatable shaft 13 having thereon a plurality of helical screw flights 14a, 14b, 14c, 14d. Shaft 13 is suspended from its upper end in a housing 15, which also houses a train of gears for speed reduction from a motor (not shown) for rotating shaft 13 at any suitable speed.

The worm flights move the material downwardly into a vertical barrel 18 which is a continuation of the chute immediately thereabove, but is of much sturdier structure, since the material to be processed begins to be pressed and compacted in this barrel. Within barrel 18 (Fig. 1) the vertical shaft carries a plurality of helical screw flights 19a, 19b, 19c, 19d. The structure of the barrel itself will be better understood by reference to prior patents to Raymond T. Anderson, including for example U.S. Patent Nos. 1,722,882 and 1,773,771. The vertical barrel is built up from an assembly of barrel bars 20 (Figs. 2, 3 and 4) lying side by side, and all fitted together in keystone-like fashion, and tightly maintained by frame members 21 and 21a which in turn are clamped by bars 22, 23, 24 and 25 retained by tie bolts 26 and 27. The barrel bars 20 are disposed in such close lateral contact as to prevent solid material from escaping radially therebetween, but to permit liquid to be squeezed through the minute interstices when the pressure is heavy. Spacers 20a may, if desired, be placed between the barrel bars, although such spacers may be dispensed with, especially when certain designs of barrel bar are used, as shown in Figs. 5, 6, and 7. By the use of such spacers, or by specially contoured barrel bars, drainage of liquid may be controlled, and may be restricted to the vertical barrel only, or may be permitted in part or all of the horizontal barrel now to be described. The choice of where to permit drainage depends on factors such as specific wood types and/or specific processes.

From the vertical barrel the material being processed is delivered to the horizontal barrel 28, Fig. 1, the gen-

eral structure of which is similar to that of vertical barrel 18, the section, Fig. 2, being actually taken through the horizontal barrel. Here again we have the cylindrical assembly of tightly clamped barrel bars (some-what analogous to the old familiar "barrel staves"), and here again the barrel bar assembly is encased and clamped in extremely sturdy fashion, being designed to withstand any outwardly-applied pressure which the apparatus can develop. As a matter of fact failure should occur elsewhere in the drive or the transmission before failure in the barrel assembly.

Fig. 1B shows the motor 29 and gear reduction train 30 for the right end 31a of main shaft 31.

Shaft 31 is provided with interrupted helical screw flights 31b, 31c, 31d, etc. which, in the embodiment shown in Fig. 1, decrease in pitch progressively towards the left end of the shaft. At spaced points around the periphery of barrel 28 there are "knife bars" 32 inserted between adjacent pairs of barrel bars, said knife bars having projecting portions 32a (Fig. 2) which extend inwardly into the spaces between screw flights, the purpose being to prevent material in the barrel from merely rotating with the shaft. When the material is thus obstructed from rotary motion, it is forced to the left, eventually passing through neck 35 and falling downwardly through the discharge aperture 36.

It will be apparent that pressure can be built up in press barrel 28 in a number of ways. One familiar way is to restrict the discharge opening by an adjustable choke device by which the annular clearance area between shaft end 31f and its housing can be increased or diminished. We show in sectional view in Fig. 1 the cooperating movable parts 37a, 37b, 37c, 37d, etc., of such an adjustable choke, of the type shown and described in U.S. Patent No. 1,752,054 to Raymond T. Anderson. Briefly speaking, rotation of a worm 38 produces rotation of a gear 37a which through the operation of further cooperating parts results in the constriction of inner edge parts such as 37d and 37e. The change in diameter of the choke aperture is somewhat similar to the operation of the so-called "iris diaphragm" which is used in optical elements, for instance certain camera lenses.

Restriction of the choke aperture in the manner described increases the pressure within barrel 28, assuming the shaft 31 to be rotated at uniform speed.

Pressure can also be built up in barrel 28 by progressively decreasing the pitch of worm flights 31b, 31c, etc., or by progressively increasing the diameter of the shaft while maintaining the barrel diameter uniform.

In the past the apparatus such as we have hereinabove generally characterized has been used mainly for the expression of liquid from liquid-bearing materials. A major amount of such expression generally takes place in the vertical barrel 18, and a minor proportion in the horizontal barrel 28. Because of the multiplicity of elements of the apparatus of this invention which permits a predetermined control of expression of liquids from the wood as well as a predetermined control of the degree of fiberizing attained, the amount and the place for liquid removal may be varied at different times through the vertical and horizontal sections of the apparatus of this invention. Any expressed liquid is squeezed out between the barrel bars and drops into the bed at the bottom, whence it can be drained out. Any fines, or minute particles of material settling out from the liquid collects in a trough at the bottom and is conveyed by a worm 40 to the right (Fig. 1) and thence to the end of the trough (Fig. 1B) and out through a discharge orifice 41.

Having discussed the general structure and function of the main elements of the press illustrated in the drawings, we now proceed to a more detailed disclosure of the novel processes and elements comprising our invention.

As hereinabove mentioned, conventional previous methods of fiberizing material such as wood have involved either the use of grinding stones, followed by disk refining,

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or chemical attack followed by disk refining. We have discovered that a most successful and efficient method comprises moving wood particles against wood particles under heavy pressure and we find that by means of the apparatus disclosed, with certain novel refinements to be soon described, this "self-abrasion" can be most conveniently effected. In another novel and improved aspect of our invention we have discovered that if the wood particles being fiberized as aforesaid, be subjected to self-induced heat and pressure, as a result of containment under heat and moisture conditions, and this pressure is suddenly released, the material "explodes" into individual fibers.

Referring again to the drawings, wood chips to be fiberized, or other particles such as lumber mill sawdust and planer shavings, are discharged into charging aperture 12 (Fig. 1A) and are fed by feed worm 10 into the upper end of the vertical press where they begin to be compacted in a preliminary way. As soon as worm flights 14a, 14b, etc., advance the chips into the barrel section 18, the pressure increases to between 1000 pounds per square inch and 4000 pounds per square inch, to produce, at the lower end of barrel 18, a practically solid plug of compressed wood.

Worm flight 31b of the horizontal shaft 31 is rotating at right angles to the vertical shaft, and it tears successive increments of material from the compacted plug. This angular relationship need not be a ninety-degree one, since any other relationship disposed in a motion and direction opposed to that of the arrival of the plug of chips can be satisfactorily operative. This operation produces a preliminary fiberizing of the material.

Further fiberizing takes place in horizontal barrel 28. As the shaft 31 rotates it carries the material forward and increases the pressure thereon as a result of the decreasing pitch of the worm flights and the restricted discharge aperture in the adjustable choke zone. By the rotation of each worm flight there is frictionally induced a helical motion of some of the fibrous mass in the same direction as that of the motion of the worm. In this way further rubbing of partially fiberized wood chips against other partially fiberized wood chips occurs. As a result of the use of a multiplicity of worms 31b, 31c, 31d, etc., this self-induced frictional abrasion and fiberizing continues as far as the choke aperture.

The chip material carries a certain amount of moisture therein, which may be any suitable liquid, the most usually used liquid being water, in a range between about 35% to 80% and preferably at or in excess of 50%. As a result of the tremendous pressure developed in the horizontal barrel, and the friction between the relatively moving wood particles, and between the said particles against the worms, the barrel bars, and the knife bars, the temperature within the horizontal barrel rises above the boiling point, usually above 212° F., and frequently between 220 F. and 250° F. We therefore have a condition of varying equilibrium between super-heated moisture and super-heated steam or other vapor which exists even in the intimate zones between individual neighboring fibers. As the compressed material is forced through the choke aperture, which may be in the neighborhood of one-eighth of an inch in radial dimension, and is discharged into an atmosphere pressure zone, the restriction is suddenly released, and the superheated steam explodes the fibrous texture into individual fibers in such fibrous bundles as have not previously been fiberized.

To accentuate the fiberizing effect we have provided an additional improvement which we have illustrated in Figs. 3 and 4. These views show "carrying bars" 44 and 45 attached to the screw flight hubs, which of course are keyed by a member 46 to the central shaft 47. The carrying bars cause the wood chips or fibrous bundles or aggregates to rotate with the shaft to a much greater degree than the rotation possible with the plain cylindrical surfaced shaft of Fig. 1. It will be further observed that the clearance space between the shaft surface (or more

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correctly the outer surfaces of the screw flight hubs) and the inner periphery of the barrel decreases in radial dimension towards the left or discharge end, which of course increases the pressure on material being forced to the left.

Other modifications of our invention for increasing the fiberizing action are shown in Figs. 5, 6 and 7, involving, in each instance, a change in the inner part of each barrel bar.

In Fig. 5 we show barrel bars 49 in which the inner faces 49a are beveled to provide a retaining edge 49b which projects inwardly and intercepts the outer peripheral portion of the fibrous material which is being forced helically in the direction of the arrow, as well as longitudinally towards the choke. This design of the inner face of the barrel bar provides pockets 50 for transitory retention of fibrous material so that other material immediately clear of the pocket can be drawn across the trapped material, thus producing a wood-against-wood abrasive action for better fiberizing. Spacers can also be used between barrel bars 49 to provide drainage of liquid therebetween when the occasion requires it. One type of spacer is shown at 20a in Fig. 4, but a number of suitable types are familiar to those skilled in the art.

In Fig. 6 the effect described in Fig. 5 is somewhat less accentuated since only a portion 51a of the barrel bars 51 is tapered or beveled. This results in a smaller trapped pocket 52.

In Fig. 7 we show a further modification wherein the leading face 53a of barrel bars 53 is formed with a convexity 53b which provides an additional retaining effect for the pocketed material.

In the embodiments shown in both Figs. 6 and 7 spacers can be used if desired.

The various angularities of the inclined inner faces of the barrel bars are not critical, and any configuration is helpful which induces a frictional drag on the advancing material. Merely as an illustrative example we have actually used a seven-degree taper on the inner faces 49a of a barrel bar assembly such as shown in Fig. 5.

Another embodiment of the invention is seen in Fig. 8. In this embodiment, which deals only with the press barrel and its shaft, we show a stepped down barrel having a larger diameter portion 58, a smaller diameter portion 59 and an intermediate portion 60 which is frusto conical in contour. The fibrous material is introduced at the right end, and is advanced towards the left end by shaft 61 which carries successive worm flights 61a, 61b, 61c, etc.

In this embodiment the barrel is formed from an assembly of barrel bars but these are arranged in zones, as best shown in Fig. 9, the bars in one zone being angularly inclined to the bars in an adjoining zone, the bars in adjacent zones being therefore out of longitudinal alignment with each other. Referring to Fig. 9 it will appear that the bars in zone "A" run longitudinally each in an axial plane through the shaft axis "X." The bars in zone "B" are inclined in planes which intersect the shaft axis at a predetermined angle. The bars in zone "C" are inclined at yet another angle, opposed to that in zone "B." The bars in zone "D" are again in planes coincident with the shaft axis.

The purpose of this arrangement is as follows. The barrel bars are of the type shown in Figs. 5 and 6 wherein the bars have inwardly projecting edges to intercept the material and increase the frictional effect. At one inclination, such as in zone "B," the material is advanced generally along the direction of bar inclination, but for example in zone "C" the bars are inclined more or less in opposition to the direction of material movement. As a result the frictional effect can be augmented or lessened in a predetermined manner in predetermined zones of the press barrel. We do not intend to be restricted to the exact design shown since our concept includes the use of barrel bars with any desired number of direction rever-

sals in any barrel zone, and adaptable to the barrel length. We have shown both the concepts of barrel bar inclination and step-down barrel diameter in the same two drawings, in use simultaneously, but it is obvious that either concept may be used separately, without the other.

It will further be noted that the screw flight in the intermediate portion 60 of the barrel has an outer edge contour of frusto-conical character to fit the frusto-conical inner wall of the barrel portion 60. This step down of course causes an increased pressure on the moving material.

As heretofore intimated the apparatus and process herein defined may be applied in mechanical fiberizing processes as well as in combined mechanical-chemical processes. The digested pulp from the latter classification is of course much softer and more readily macerated than the harder wood fragments from the preliminary mechanical steps. We have found that the simplest arrangement first described in connection with Figs. 1 and 2 is usually quite adequate to completely pre-fiberize digested pulp. As the difficulty of the operation increases, using undigested fragments, namely the straight mechanical process, we may put in effect varying degrees of severity of fiberization. For example we may use, with the first embodiment described herein (Figs. 1 and 2) the additional feature of the carrying bars at the root of one or more screw flights. For a still further increase in fiberization effect we may add to this embodiment the protruding cutting edges of the barrel bars as shown in Figs. 5, 6 and 7, or we can use either of these last three modifications without the carrying bars. In this way the degree of fiberizing may be accurately pre-selected. The carrying bars may be used either on the worm hub itself, or on collars on the shaft, for example on the collars 42 of Fig. 4, or on spacing collars between the worms. These carrying bars may also be attached to the screw flight hubs or collars at any desired angle to either expedite or retard the advancement of the material by the worms. Both the carrying bars 44 and the fiberizing angled barrel bars can of course be used either in the vertical barrel or the horizontal barrel. The shaft may also be made with the worms and collars integrally attached thereto, for example by welding.

Fig. 10 shows an embodiment wherein a solid barrel 63 is provided with interior grooves 64 spaced apart by lands 65 and parallel to the tube axis. This arrangement serves to provide recesses for intercepting and temporarily holding some of the material across which other fragments of material are dragged by a worm shaft (not shown). The grooves can be helically inclined.

With all such embodiments it is desirable that the "explosion" effect be developed at the choke discharge face. Operating temperatures within the horizontal barrel will naturally rise above room temperature by reason of friction accentuated by heavy pressures but such developed temperatures may be controlled in ways not disclosed herein, such as by the application of cooling or heating media to the outer surfaces of the press barrels or through the usually hollow interior of the press shafts.

In certain processes for the pulping of wood, however, specific and lower temperature control of the wood being processed through the apparatus of this invention is necessary. One of the illustrations of this type of pulping is the cold alkaline system. In one embodiment of it the digested pulp being processed through the apparatus of this invention should not exceed 60° C. In these specific instances the shaft that may be selected for the specific work; for example the horizontal shaft as illustrated in Fig. 1, may have a hollow core for water cooling of the shaft. Additionally liquors expressed from the wood by the apparatus of this invention may be cooled and flowed onto and over the barrels of the apparatus according to this invention. By these means the temperature of the fiberized wood issuing from the apparatus of this invention has been controlled to temperatures lower than 40°

C. By these two convenient means of cooling liquid and spraying of liquors over the barrels, a precise degree of control of the temperature of the fiberized wood may be attained. Contrarywise, if it be necessary in the processing of certain woods that elevated temperatures are beneficial, heating fluids may be pumped through the hollow cored shaft or shafts and heated liquids may be pumped and flowed over the barrels of the apparatus of this invention in order to attain and maintain elevated temperatures.

The fiberized material issuing from the choke at the discharge end of the main press barrel may be subjected to the usual screening and disk-refining steps now familiar in the pulp paper industry.

The cost of producing fiberized and refined pulp on a per-ton basis by our process, in the equipment described, is approximately one-half that of producing material by conventional prior art processes.

The basic underlying principle of the present invention comprises the compression of wood chips or particles to form, in effect, a plug, and the mechanical tearing off of layers from this plug by a force applied at an angle to the plug. While these steps can be performed by any suitable apparatus, we have illustrated one preferred apparatus and several novel modifications thereof. In combination with the novel steps recited above considerably improved fiberization can be obtained by the "explosion" effect hereinabove described. Further, any additional means whereby wood fragments may be forcibly dragged across other wood fragments is definitely helpful.

It may be further remarked that any of the mechanical features shown and described with reference to the horizontal press barrel may likewise be utilized in the vertical press barrel, such as the knife bars, carrying bars, barrel bar cutting edge contours, flight pitch variations, or constrictions for the annular clearance space between the shaft and the inner periphery of the barrel. The spacing between the barrel bars may be any predetermined amount, such as .010", .020", or .030" or otherwise. This permits expulsion of excess or unwanted liquids from the fibrous material, and such dewatering may be effected either in the vertical barrel or the horizontal barrel. Such de-liquification can be arranged, by barrel bar spacing in conjunction with other features, at any desired point or zone of the barrel, it being sometimes desirable to locate and adjust the consistency of the fibrous material for the optimum defiberizing desired. The fiberized material may then be mixed with a small amount of water and conveyed to a standard finishing refiner for the production of usable pulp.

One interesting adaptation of the invention is of advantage in the production of kraft pulp. When certain woods are cooked by the kraft method, fibrous pulp masses issue from the digestors. These pulp masses are screened to remove the undigested knots from the kraft pulp. Such knots are usually discarded before the pulp is further refined and converted into paper. By the use of the apparatus of this invention the kraft pulp from the digester may be de-watered for the reclamation of the chemicals in the digestion liquor. At the same time when liner board or paper is being prepared from kraft pulp the knots may be left with the pulp for processing in the apparatus of this invention, so that the knots themselves are fiberized to a pulp. In such manner the apparatus of this invention is used as a deliquefying apparatus while at the same time fiberizing the kraft knots, thus increasing the yield of pulp from the mill operation.

Although the fundamental principle of this invention has been described in connection with the press assembly shown in the drawings, other suitable mechanisms capable of compressing fibrous material could be used, for example a piston for compacting raw or cooked wood fragments which compacted aggregate could then be defiberized by counter-movement of another mechanism such as the worm shafts shown in the drawings.

In one test of a machine designed in accordance with Figs. 1, 1A and 1B of the present drawings, we were able to produce 45 tons per day of oven-dry fiber from semi-chemically digested wood chips. In the same plant, using prior art practice, and standard semi-chemical processing equipment using the same power input as the machine mentioned above, about 12 tons per day of dry cooked fiber was produced per day. The power saved by the use of our process and apparatus will pay for the cost of the apparatus in approximately one year.

It is well known to those skilled in the art that the electrical energy required in the pulp and paper field is of a relatively high order per ton of wood processed. This materially increases the cost of the process as well as the necessity of utilizing heavy equipment which can handle so much energy. Since the apparatus we have disclosed herein decreases the amount of required horsepower by one half or more, the power and equipment saving to the industry will be readily apparent to those skilled in the art.

What we claim is:

1. In a process of fiberizing fibrous material the steps comprising compressing said material in an enclosure to form a compacted plug, moving said plug through and out of said enclosure, advancing cutting means across the leading face of said plug whereby to shear off fragments of said plug, and moving said fragments through a second enclosure in such manner as to cause frictional drag of some fragments across other fragments, while maintaining all said fragments under heavy mechanical pressure increasing to a figure in excess of one thousand pounds per square inch.

2. In a process of fiberizing fibrous material the steps comprising mechanically compacting fragments of said material in a first enclosure while moving the material therethrough, whereby to discharge from said first enclosure a compacted plug of said material, moving material-contacting means across the face of said plug as it issues from said first enclosure whereby to rub particles of the material from said plug, moving said particles through a second enclosure while causing some of said particles to frictionally drag across other particles under heavy pressure in excess of one thousand pounds per square inch and extruding the mass of said particles through a restricted discharge opening into a zone of released pressure.

3. A process as defined in claim 2 wherein the material advancing through said second enclosure is maintained at a temperature above 212° F.

4. A process as defined in claim 3 wherein the material contains a water component in amount between thirty percent and eighty percent by weight.

5. A process as defined in claim 2 wherein the material is maintained under a mechanical pressure of more than 1000 lbs. per square inch in both said first and second enclosure.

6. An apparatus for fiberizing fibrous particles comprising an elongated barrel of cylindrical contour having a peripheral wall formed from an assembly of elongated barrel bars extending longitudinally side by side, means for retaining each of said bars in tight contact with the bar on each side thereof, there being minute interstices between bars to permit escape of liquid therethrough, a rotatable shaft extending coaxially within said barrel, a plurality of helical screw flights carried on said shaft, means for charging said particles into said barrel at one end whereby upon rotation of said shaft and said helical flights the particles are carried from said one end towards a discharge end, and means carried on said shaft in addition to said screw flights for producing frictional drag of some of said particles against others of said particles.

7. Apparatus as defined in claim 6 wherein the means last-mentioned in claim 6 consists of a protuberance on said shaft, between adjacent screw flights, and extending

radially outwardly beyond the cylindrical periphery of said shaft.

8. An apparatus for fiberizing fibrous particles comprising a first barrel and a second barrel, each having respective charging and discharging ends, the discharging end of the first barrel being adjacent to the charging end of the second barrel whereby material discharged from said first barrel enters said second barrel, means in said first barrel for receiving, and compacting said particles, and for simultaneously advancing the compacted mass towards the discharge end, means in said second barrel near its charging end for moving transversely across the leading face of the advancing compacted mass and shearing off successive fragments of said mass for transmission through said second barrel, and means in said second barrel for inducing self-abrasion among said fragments by frictionally forcing some of said fragments against and across other said fragments, while maintaining all said fragments under heavy mechanical pressure increasing to a figure in excess of one thousand pounds per square inch.

9. An apparatus as defined in claim 8 wherein the said barrels are disposed so that their respective axes are inclined angularly relative to each other.

10. An apparatus as defined in claim 8 wherein the respective axes of said barrels are disposed at right angles to each other whereby to accentuate the frictional effect of the shearing operation.

11. Apparatus as defined in claim 8 wherein at least one of said barrels is formed from an integral length of cylindrical tubing, the interior peripheral wall of said tubing being provided with a plurality of grooves running longitudinally of said wall and generally parallel to the tubular axis.

12. Apparatus as defined in claim 8 wherein at least one of said barrels is formed from an integral length of cylindrical tubing, the interior peripheral wall of said tubing being provided with a plurality of grooves running generally longitudinally and helically with respect to the tubular axis.

13. An apparatus for fiberizing fibrous particles comprising an elongated barrel of cylindrical contour having a peripheral wall formed from an assembly of elongated barrel bars extending longitudinally side by side, means for retaining each of said bars in tight contact with the bar on each side thereof, there being minute interstices between bars to permit escape of liquid therethrough, a rotatable shaft extending coaxially within said barrel, a plurality of helical screw flights carried on said shaft means for charging said particles into said barrel at one end whereby upon rotation of said shaft and said helical flights the particles are carried from said one end towards a discharge end, and means carried on said screw flights for producing frictional drag of some of said particles against others of said particles.

14. In a process of treating fibrous materials containing between thirty percent and eighty percent of liquid, the steps comprising continuously compacting and fiberizing said material under relatively heavy mechanical pressure in excess of 1000 pounds per square inch in an enclosure at a temperature in excess of the boiling point of the liquid but less than 275° F., so as to cause a development of steam pressure, and immediately thereafter continuously ejecting said material from said enclosure to cause it to suddenly release the relatively low steam pressure increment.

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