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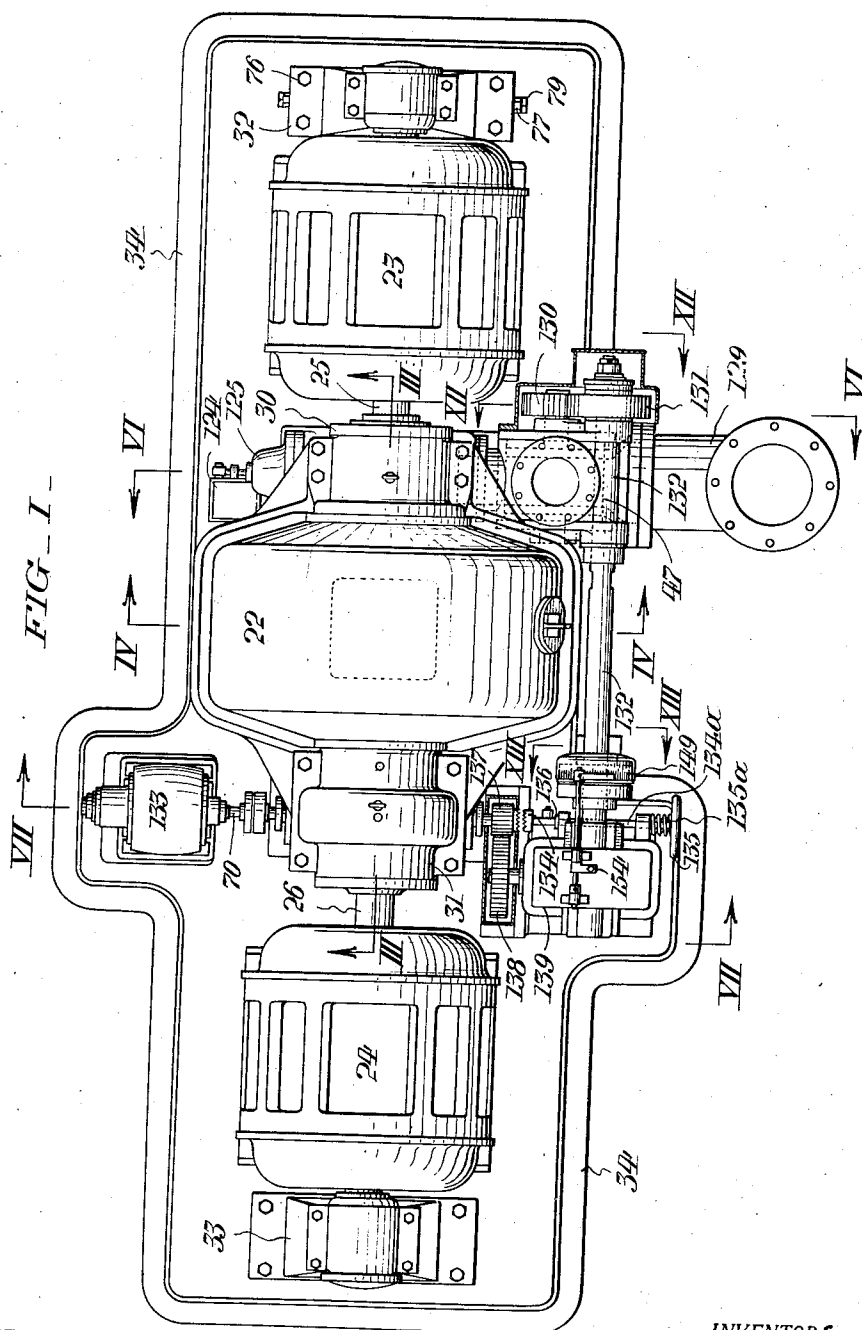
F. S. FARLEY ET AL

1,984,869

PULP REFINING AND THE LIKE, AND APPARATUS THEREFOR

Filed May 23, 1931

6 Sheets-Sheet 1



WITNESSES
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FIG. II.

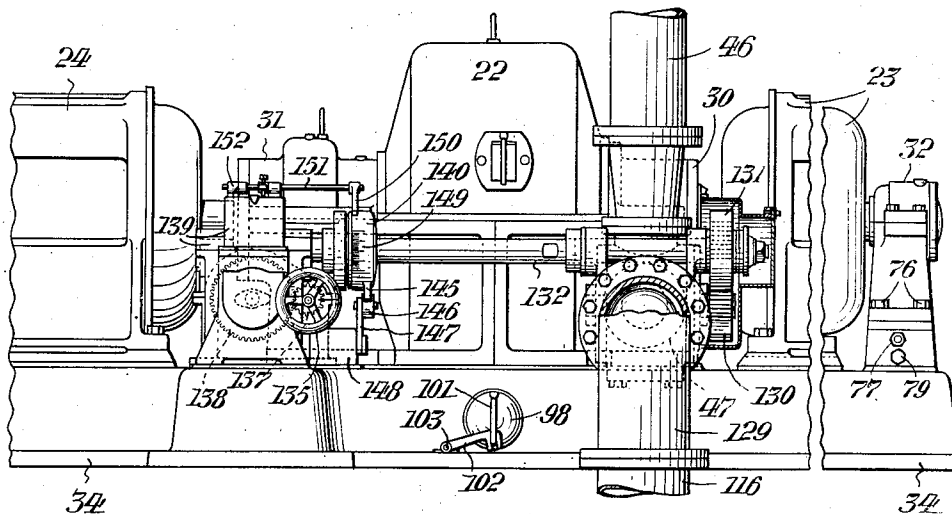
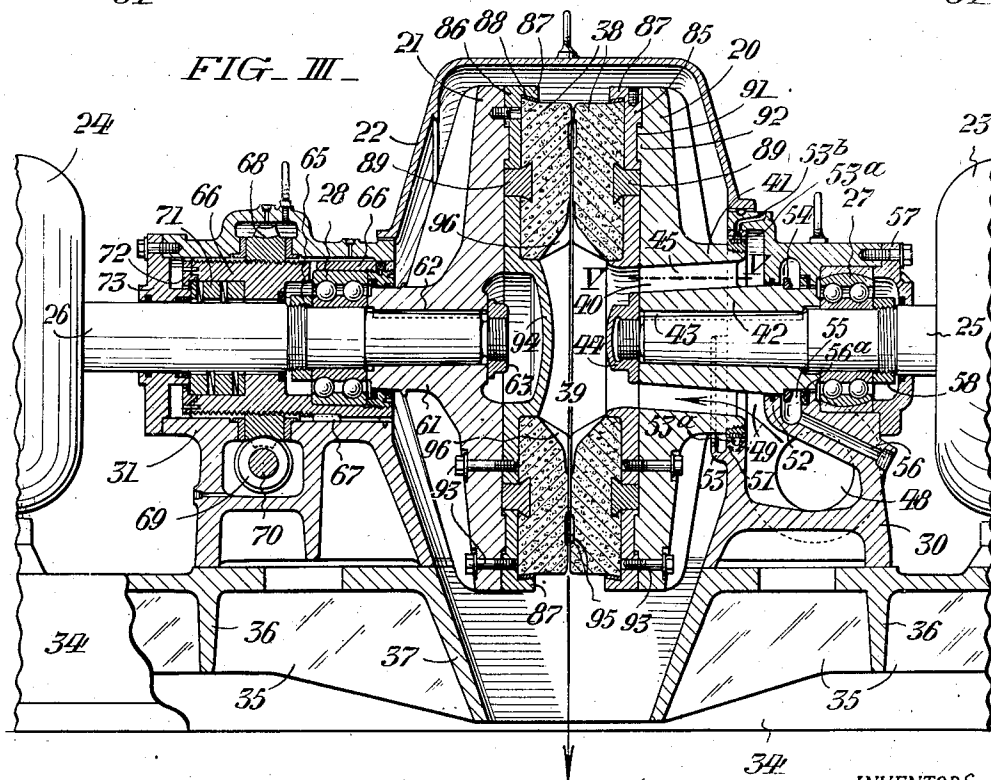


FIG. III.



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FIG. IV

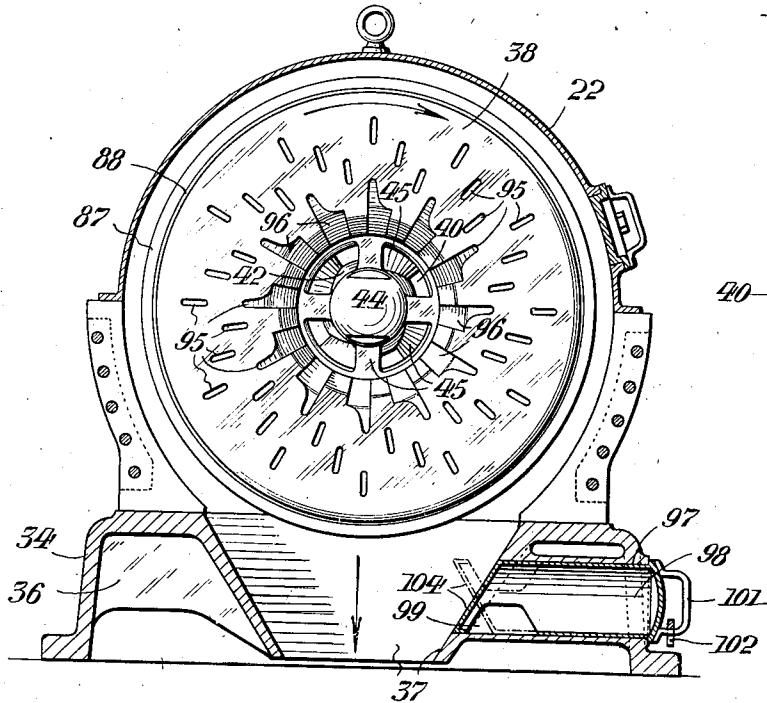


FIG. V

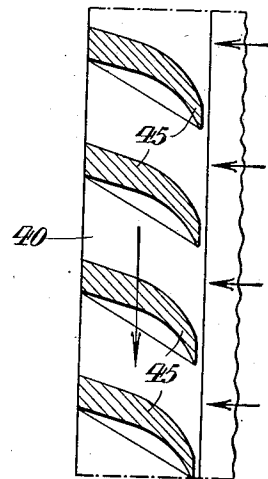
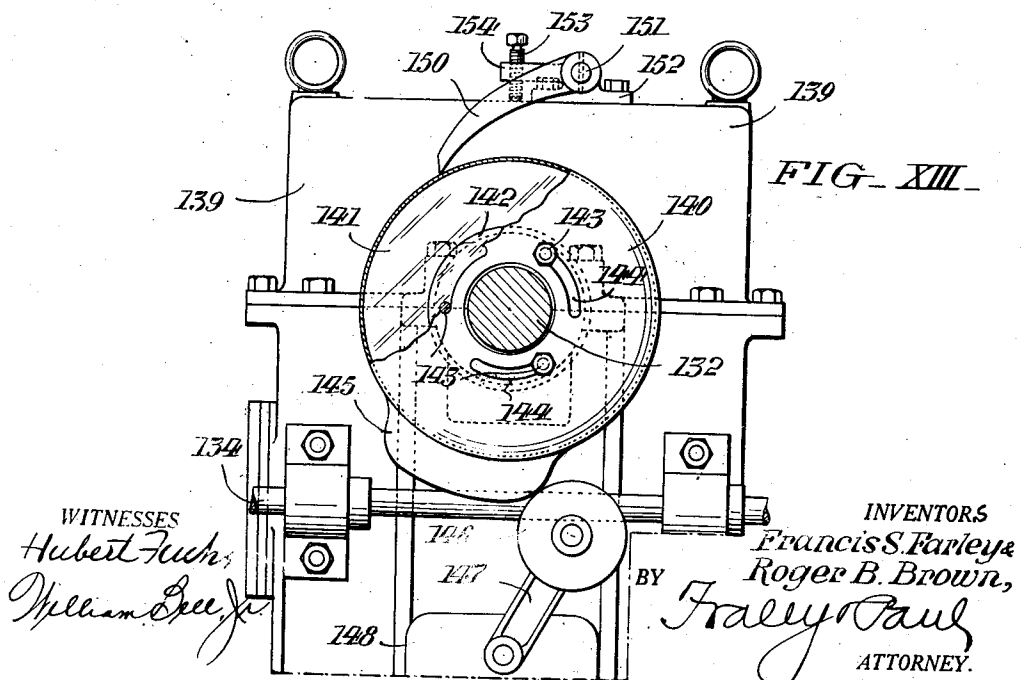


FIG. XIII



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FIG. VII-

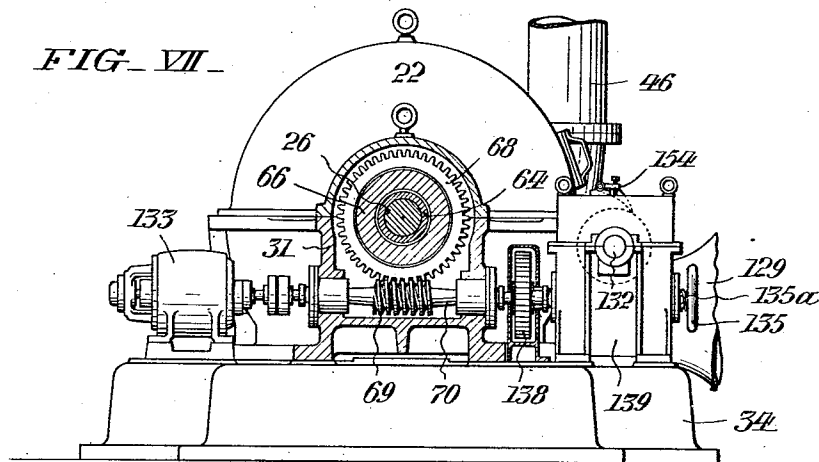


FIG. VI-

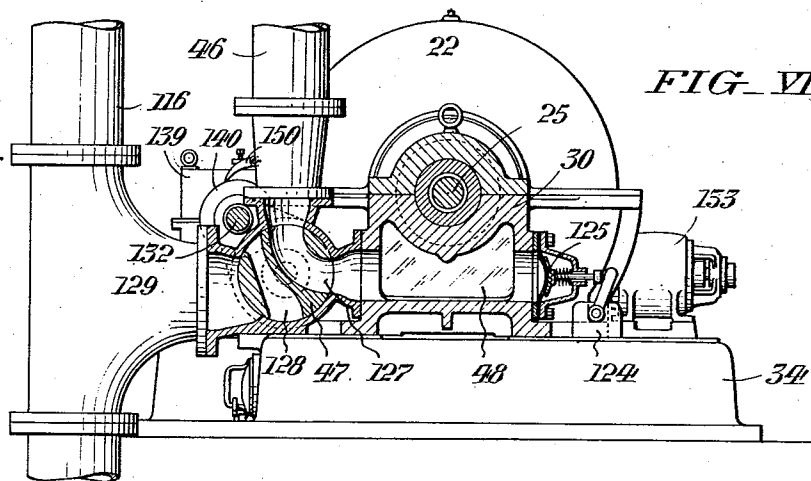
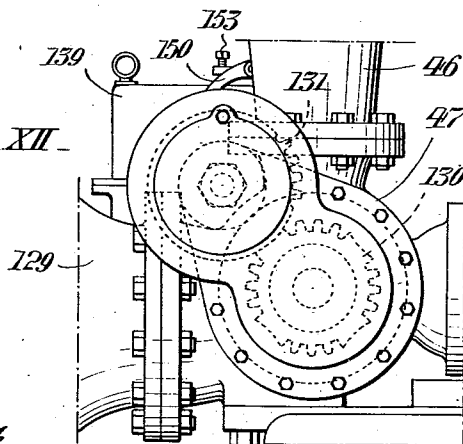


FIG. XII-



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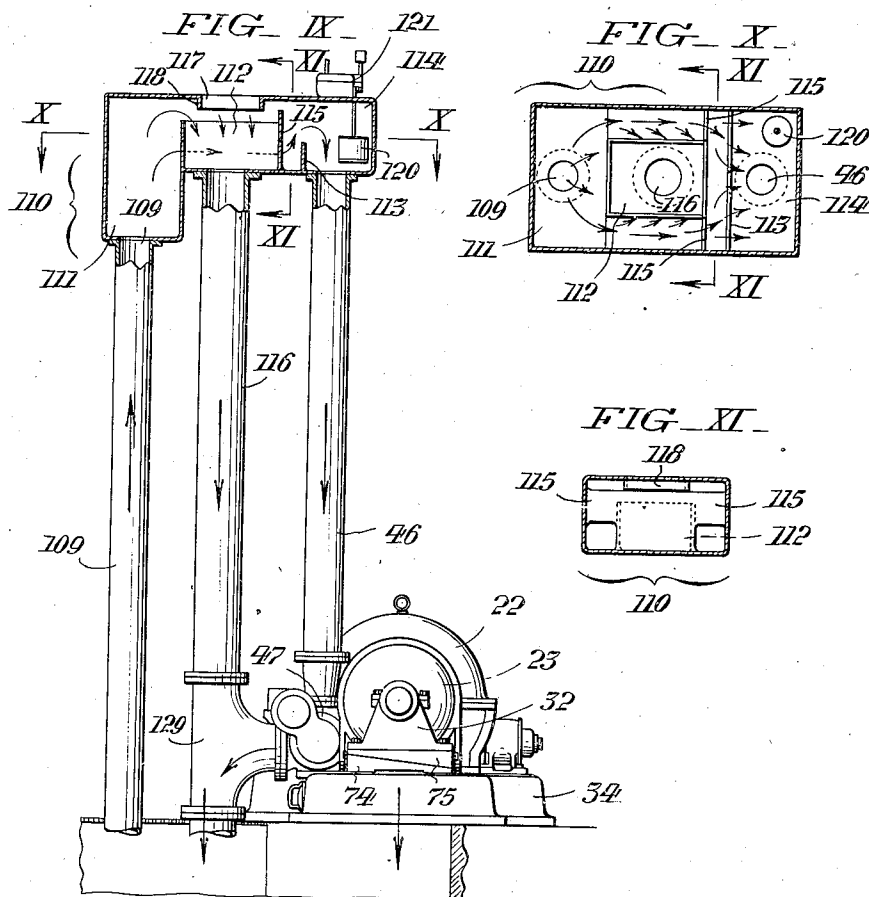
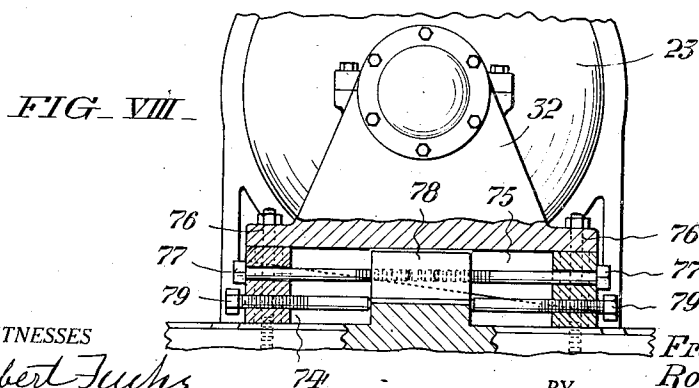
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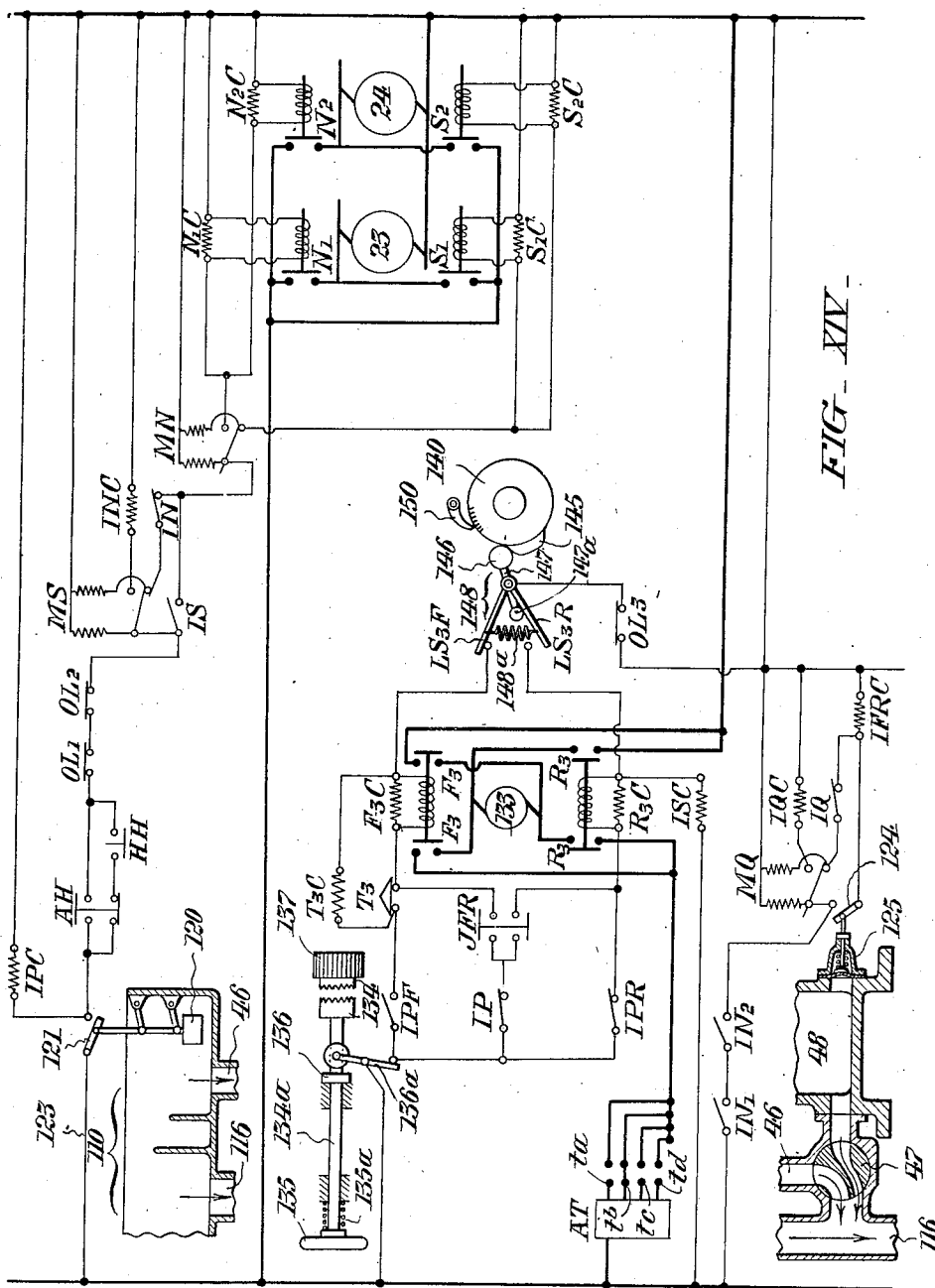
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UNITED STATES PATENT OFFICE

1,984,869

PULP REFINING AND THE LIKE, AND
APPARATUS THEREFORFrancis S. Farley and Roger B. Brown, Trenton,
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Application May 23, 1931, Serial No. 539,438

51 Claims. (Cl. 92—26)

Our invention relates to the refining of fiber pulp, such as various kinds of wood pulp, paper pulp, and leather pulp, and also fibrous or cellular materials not in liquid suspension, such as cork and other substances. The invention includes a novel machine or apparatus for this purpose, and various improvements in connection therewith. We aim to overcome drawbacks of refining machinery heretofore used, and to secure other advantages.

In refining machines heretofore used, the reduction of the fibers is produced by forcing, rubbing, or rolling the fibers through small clearances under some pressure, and in the presence of water. The types of refiner referred to include rod mills, beaters, Jordans, Claflins, and attrition mills. As heretofore constructed, however, these machines are subject to some or all of the following disadvantages: i. e., they give a pulp of short fibre-length, or of low viscosity, or they accomplish only a small reduction in "freeness", or they pass some fibers unreduced or insufficiently reduced. Quite generally, also, the power consumption is high and the efficiency poor, especially after wear of the active parts, and frequent replacements of worn parts are therefore necessary.

Attrition mills with metal plates, which are in some respects a preferred type of refiner, are subject to serious wear. Moreover, as their coating plates or discs are urged together by springs, the plates rub on each other when the machine is running empty; and when stock is fed to the machine, they spread apart more or less, according to the coarseness of the fiber bundles passing between them. Hence the product is not uniform, because the clearance between the discs varies during operation. Variation of the working clearance and poor refining also arise from deflection of the disc faces out of strict parallelism, owing to the high pressure between the discs.

As herein illustrated and described, our preferred machine resembles the attrition mill type, but is free of the drawbacks just discussed: i. e., its discs can be "dead" set at an absolutely fixed clearance, and deflection under operating pressure entirely avoided,—so that substantial uniformity of the refined fibres is assured. The clearance can be easily and accurately adjusted, and can be made and maintained as fine as desired,—much finer than in attrition mills as heretofore known. By virtue of the fixed working clearance and of the abrasive characteristics and facial features of the discs, the original length of the fibres can be very largely preserved. The

pulp can be treated at a higher consistency than heretofore, which increases the efficiency: indeed, the pulp can be refined at a higher consistency than when it enters the machine; and if desired, part of its water can be caught and led away, so that the final product shall have a greater consistency than the initial stock.

The machine can also, if desired, be controlled and operated automatically,—either completely so, or to a greater or less degree, as desired.

Other improvements and advantages over prior machines will become apparent to those skilled in the art from the description hereafter of a preferred form of machine embodying the invention.

In the drawings, Fig. I is a plan view of a refiner conveniently embodying our invention.

Fig. II is a side elevation of the machine with certain portions broken away and removed.

Fig. III shows a vertical section through the mid portion of the machine, taken as indicated by the line and arrows III—III in Fig. I, on a larger scale than Figs. I and II.

Fig. IV shows a vertical section through the machine between the refining discs or rotors, taken as indicated by the line and arrows IV—IV in Fig. I.

Fig. V shows a "developed" cylindrical section through the pulp intake or feed passage of one of the rotors, taken as indicated by the dot-and-dash line V—V in Fig. III.

Fig. VI shows a vertical section through the pulp supply passage of the machine and certain associated parts, taken as indicated by the line and arrows VI—VI in Fig. I.

Fig. VII shows a vertical section through certain portions of the disc-adjusting mechanism of the machine, taken as indicated by the line and arrows VII—VII in Fig. I.

Fig. VIII is a fragmentary end view of the machine from the right of Fig. I, with certain portions broken out and removed to expose the provisions for adjusting a bearing.

Fig. IX is an end elevation of the machine and its pulp feeding provisions, certain parts being in vertical mid-section.

Fig. X shows a horizontal section through part of the pulp feeding means, taken as indicated by the line and arrows X—X in Fig. IX.

Fig. XI shows a vertical cross section through the pulp feeding means, taken as indicated by the line and arrows XI—XI in Fig. IX.

Fig. XII is a fragmentary side view of mechanism for operating the pulp supply control, taken as indicated by the line and arrows XII—XII in Fig. I.

Fig. XIII is a detailed view, in elevation, of a portion of the disc-adjusting mechanism, with certain parts in vertical section as indicated by the line and arrows XIII—XIII in Fig. I, and with certain parts partly broken away.

Fig. XIV is a diagram of the electrical features and connections of the machine and its associated parts.

Referring to Figs. I, II, and III, it will be seen that the particular machine here shown comprises oppositely rotating coacting refining members or discs 20, 21 enclosed in a casing or housing 22, and driven by separate (electric) motors 23, 24 mounted directly on the rotor shafts 25, 26. The rotor shafts 25, 26 are mounted in inner anti-friction (thrust) bearings 27, 28 in pedestal supports 30, 31 located closely adjacent the rotors 20, 21 and forming part of the housing structure 22, and in outer (journal) bearings in other pedestals 32, 33, at the outer sides of the motors 23, 24. The pedestals 30, 31 are tied and united to the casing 22 proper by longitudinal webs below the shafts 25, 26, as well as by the structure around these shafts. All of these and other parts (hereinafter described) are mounted on a common rigid base 34, stiffened by a marginal apron and by suitable longitudinal and transverse flanges 35, 36. As shown in Fig. III, the base 34 has therein an opening with a depending inward-sloping apron or flange 37 that forms a downward extension of the refiner housing 22 and a downward discharge for the pulp refined between the rotors 20, 21.

As shown in Figs. III and IV, the refining members 20, 21 have flat, annular, abrasive stone working faces 38, 38, with a central cavity or chamber 39 whence the pulp works its way out between the faces in a thin annular stream or "sheet". Pulp is admitted to the cavity 39 through the disc member 20, which has an annular intake passage 40 in its central hub portion 41, around its inner hub 42,—in which the shaft 25 is keyed at 43 and secured by a cap nut 44. This inner hub 42 is connected to the outer hub 41 by curved vanes 45 inclined across the passage 40 (with concave faces forward) as shown in Figs. IV and V, so as to draw in the inflowing pulp and force it through into the chamber 39. Pulp is supplied to the machine by a pipe 46 and valve 47 (Figs. II and VI) connected to a passage or chamber 48 in the pedestal 30 below its bearing 27. From the chamber 48, the pulp ascends to the intake 40 through a narrow passage 49 between the bearing 27 and the outer hub portion 41, around the inner hub 42. The chamber 48 is shown comparatively broad and large, so that the pulp passes through it slowly enough to cause any metal or mineral matter in the pulp to settle out: in other words, the chamber 48 acts as a trap to collect any metal in the pulp and protect the machine from damage thereby.

The joints 51, 52 between the walls of the passage 49 and the hub portions 41, 42 may be made reasonably fluid-tight by any suitable means, such as worm threads on the hub 41 coacting with the cylindrical inner surface of the wall adjacent the casing 22, and a packing ring in a groove in the other wall making contact with the hub 42. The packing threads at 51 are so arranged as to pump refined pulp collecting in a semi-circular trough 53 inside the casing 22 outward into the intake 49, thus insuring against leakage the other way, which would pollute the refined pulp with unreduced fiber. If found advisable, a circular groove 53a may be cut in the midst of the casing surface 51 and supplied with water (or refined pulp) at

53b under sufficient pressure to make passage of unrefined pulp through this joint absolutely impossible. Any leakage working through the outer joint 52 is thrown off the hub 42, by a slinger ring 54 thereon, into an annular chamber 55, whence it may be drained away through a passage 56. Packing 56a is also shown at the side of the chamber 55 adjacent the bearing 27, as an additional protection against pulp working into the bearing. As shown, the ball bearing 27 is of a double row, spherical-seated thrust type, mounted in the outside of the pedestal 30 and held in place by a cover 57 bolted to the pedestal and by a nut 58 threaded on the shaft 25. Removal of the part 58 permits access to the bearing 27 for inspection, cleaning, etc.

The disc member 21 has a hub 61 keyed on the end of the shaft 26 at 62 and secured by a nut 63. The corresponding ball bearing 28 is of a double row thrust type, with its inner race clamped against the disc-hub 61 by a nut 65 threaded on the shaft 26, and its outer race mounted in a separate box or sleeve 66. The box 66 is movable lengthwise in the pedestal 31, but is kept from turning therein by a groove and feather engagement at 67, and is externally threaded to take a worm-wheel nut 68 that can turn between abutment shoulders in the pedestal. The nut 68 can be turned either way by a sub-jacent worm 69 on a transverse shaft 70 mounted in bearings in the pedestal 31 (Fig. VII). In the enlarged outer end of the box 66 is mounted a helical compression spring 71, held in place by a removable flange-ring 72. This spring 71 is adapted to engage and be compressed against an annular abutment ridge on a cover 73 bolted to the outer side of the pedestal 31, for a purpose to be explained hereinafter.

It will be seen that by turning the shaft 70 and the nut 68 one way or the other, the disc 21 can be shifted toward the disc 20, into effective refining proximity thereto, or away from the disc 20, so as to afford a large interval between the discs. Also, the refining clearance between the discs 20, 21 can be adjusted to just the number of thousandths of an inch desired, according to the character of the pulp being treated and the fineness of fiber desired in the product.

As shown in Figs. II, VIII, and IX, the bearing in outer pedestal 32 is vertically adjustable, so as to tilt the shaft 25 up or down to true the disc 20 with the disc 21. For this purpose, transversely adjustable (hollow) wedges 74, 75 are interposed between the foot of the pedestal 32 and the sub-jacent end of the machine base 34. Bolts 76 fixed in the base 34, to anchor the pedestal 32 thereto, extend through transversely elongated holes in the ends of these wedges 74, 75. Each hollow wedge 74, 75 has in its large end an upper tension bolt 77 threaded into an upstanding lug 78 on the base 34 within the wedges, and also a lower "set screw" bolt 79 threaded through the end of the wedge and abutting against the lug 78 below the bolt 77. To raise the pedestal 32, the nuts on the bolts 76 are loosened, and the bolt 79 for either or each wedge 74, 75 is loosened and the corresponding bolt 77 taken up, after which the nuts on bolts 76 are tightened again; to lower the pedestal, this procedure is reversed as regards bolts 77 and 79. On loosening the bolts 76 without disturbing the bolts 77, 79 the pedestal 32 can be adjusted sideways to true the shaft 25 horizontally, by taking advantage of the clearance around the bolts 76 in the pedestal.

It will be seen, therefore, that the discs 20, 21

can be fully adjusted to make them run perfectly true at the exact working clearance desired. Furthermore, as the thrust between the discs 20, 21 is taken at the closely adjacent inner pedestals 30, 31, instead of at the outer pedestals 32, 33, its leverage for distorting the base 34 is minimized, as well as the length of the base that must be most strongly braced (by the flanges 35, etc.) to obviate appreciable distortion, and consequent untruing of the discs 20, 21. Indeed, the disc thrusts can scarcely affect the base 34 at all, since they are taken and absorbed directly by the casing 22 which interconnects the pedestals 30, 31 in the horizontal plane of the shafts 25, 26, as well as below these shafts. In other words, the casing structure 22 affords a balanced connection between the thrust bearings at 30, 31 which takes the disc thrusts as a mere direct pull, substantially without any tendency toward untruing of shafts and discs. Running true, the stones 38, 38 wear quite evenly, so that the only dressing ever required is occasional deepening of the grooves in the stones.

Referring to Fig. III, it will be seen that the annular stones 38, 38 are mounted in shallow annular seats in metal backing-plates 85, 86, between inner and outer shoulders or flanges on said plates. The outer shoulders 87, 87 are undercut, and babbitt or other suitable filling 88 is introduced between them and the correspondingly bevelled rear corners of the stones 38, 38, to hold the stones securely in the plates. The stones 38, 38 are additionally secured by anchors 89 dovetailed into the stones and fastened into openings in the plates 85, 86. The plates 85, 86 have shallow annular grooves 91, 91 in their rear sides, to take corresponding annular ridges 92, 92 on the discs 20, 21 proper,—this engagement insuring correct assembly of the parts. The stones 38, 38 and their backing plates 85, 86 are secured to the discs 20, 21 proper by bolts 93 extending through the discs and taking into the plates. The center of the plate 85 is open, to admit the pulp from the intake 40; but the center of the plate 86 is closed by a web 94, to exclude the pulp from the nut 63.

As shown in Figs. III and IV, the coacting faces of the stones 38, 38 are flat and true with their axes of revolution, but are provided with a multiplicity of short radially extending pulp-grooves 95, arranged in a plurality of annular rows concentric with the axis of revolution. These grooves may be about $\frac{1}{8}$ to $\frac{1}{4}$ of an inch deep and $\frac{1}{8}$ to $\frac{1}{4}$ of an inch wide, and preferably curved (e. g., semi-circular) transversely. Corresponding grooves 95 in adjacent rows are not radially aligned, however, but, on the contrary, are displaced circumferentially from one another, preferably so as to form a series or set extending outward on a slope away from the direction of rotation. The successive grooves 95 in each series may overlap one another radially somewhat, as shown. The innermost grooves 95 broaden and deepen into channels 96 as they approach the bevelled edges of the central opening in the stone. For the best results the stones 38, 38 are preferably of medium grade and hardness, and of porous character. Stones that are too fine glaze and do not "work" the pulp fibers well, while stones that are too coarse cut the fibers cross-wise and allow them to pass through without sufficient reduction. Kraft pulp requires finer stones than ground wood screenings. In general, stones lying within the range of grade and fineness represented by Nor-

ton grades 40—250, hardness M—Z will meet the requirements in most cases. These are artificial stones, uniform, homogeneous and free from grain as compared with natural stones, and therefore generally preferable to natural stones.

As shown in Fig. IV, there is a cylindrical opening or bore 97 in the base 34, adapted to receive a sampler 98 in the form of a sheet metal cylinder (such as a brass tube) with an opening 99 in one side. The outer end of the sampler 98 is flanged to prevent insertion too far into the opening 97, and to form a closure for the latter, and is provided with a handle 101 adapted to be secured against displacement by means of a hook 102 pivoted on the base 34 at 103 (Fig. II). The inner sampler end 104 slopes in correspondence with the slope of the pulp outlet wall 37, and normally merges therewith as shown in full lines in Fig. IV. When the sampler 98 is turned 180° from the full line position, however, its end 104 projects into the discharging pulp stream so as to collect a sample of the refined pulp, for inspection to determine how the refiner is operating.

Figs. IX, X, and XI illustrate a preferred arrangement for feeding the machine with pulp to be refined. As shown in Fig. IX, the pulp is delivered through a supply pipe 109 into a head box 110 located above the machine, so that the pulp may flow to the latter by gravity through the feed pipe 46 and valve 47 already mentioned. Entering at the bottom of a depression or well 111, the pulp flows to the right (Figs. IX and X) to either side of an inner dam or enclosure 112, and overflows over a low transverse dam 113 into a compartment 114 to the bottom of which the feed pipe 46 is connected. In its course, the pulp has to flow under transverse barriers 115, 115 (Fig. XI) at either side of the enclosure 112, which serve to trap any foreign material in the pulp. If the supply of pulp through the pipe 109 should exceed the capacity of the machine, the excess will overflow into the enclosure 112 and be by-passed or carried off through a pipe 116 leading back to the supply of unrefined pulp,—or to any other suitable point of collection or discharge. As shown, the top of the head box 110 has an opening 117 to the atmosphere, located over the overflow at 112, 116, and having an inward directed flange 118 around it. In the feed compartment 114 is a float 120 controlling a switch device 121. So long as the supply of pulp is sufficient, the float 120 remains high enough to hold the switch 121 closed; but if the supply fails or becomes insufficient to sustain the float, the latter descends and opens the switch 121, thereby shutting down the machine, as explained hereinafter. As shown in Fig. VI, there is also a pressure switch 124, actuated by a spring-pressed diaphragm 125 at one end of the pulp feed chamber 48, so that the absence of pulp in the chamber 48 shuts down the machine, as also explained hereinafter.

As shown in Fig. VI, the valve 47 is a rotary plug valve with a curved port 127 therethrough, shown in position to connect the pulp feed pipe 46 into the feed and trap chamber 48 of the refiner, so as to supply the latter with pulp, but adapted, when the valve is turned some 90 degrees counter-clockwise, to connect the feed pipe 46 (Figs. VI and XIV) into a T connection 129 in the pipe 116, so as to by-pass the pulp supply around the refiner altogether. The valve 47 also has a port 128 to vent the refiner feed chamber 48 into the T 129 when the pulp is by-passed

thereinto. As shown in Figs. I, II, and XII, the valve 47 carries a gear 130 coacting with a gear 131 on a longitudinal countershaft 132 whose operation is explained hereinafter. The gears 131, 130 constitute an intermittent gearing such that the valve 47 is turned 90 degrees during a portion of a complete revolution of the shaft 132, remaining stationary and locked—in either the position shown in Fig. VI, or a position 90 degrees counter-clockwise therefrom—at other times.

As shown in Figs. I, II, and VII, there is a reversible (electric) pilot motor 133 directly connected to one end of the transverse worm shaft 70 for shifting the discs 20, 21 toward and away from one another. The other end of the worm shaft 70 has a clutch connection 134 to a short shaft 134a extending to a hand wheel 135 at the front of the machine, by means of which the discs 20, 21 can be manually shifted (Figs. I and XIV). A helical compression spring 135a keeps the clutch 134 disengaged except when pushed and held in by the operator. When the clutch 134 is thus held in, a collar 136 on the shaft 134a opens a self-closing safety cut-out switch 136a in a control circuit of the pilot motor 133, making it impossible to start the motor. On the front end of the transverse shaft 70 is a pinion 137 meshing with a gear 138 connected to a reduction gearing 139 that is connected to the countershaft 132, which is thus always operated with and by the shaft 70.

As shown in Figs. I, II, and XIII, there is a pot-like drum 140 mounted on the shaft 132, with its peripheral wall engaged around a flange 141 on the shaft, and its web or "bottom" clamped to another flange 142 by three bolts 143 extending through slots 144 in the drum bottom. On the periphery of the drum 140 (at its lower side) is a cam 145 adapted to engage the roller or other head 146 on the double-acting operating lever 147 of a limit switch 148 controlling the pilot motor 133. The length of the cam 145 is such that when the motor 133 is bringing the discs 20, 21 together, the cam will throw the switch lever 147 one way and stop the motor as the discs reach the proper working proximity or clearance (such as 0.006 in., for example) for refining the pulp as desired; while when the motor 133 is separating the discs 20, 21, the cam will throw the switch lever 147 the other way as the discs reach the desired distance apart (such as $\frac{1}{2}$ in.). By loosening up the bolts 143, the drum 140 can be angularly adjusted to vary the working clearance between the discs 20, 21, or to correct for increase in the clearance due to wear of the stones 38, 38.

It will be understood that as the discs 20, 21 approach each other, the valve 47 is operated to turn pulp into the machine, by the interaction of the gears 131, 130, during the last $\frac{1}{8}$ in. (say) of the relative movement of the discs; while as the discs 20, 21 are separating, the valve 47 is operated to shut off the pulp from the machine and divert or by-pass it around the latter. This action is secured by the intermittent gearing 131, 130. Thus pulp only flows through the machine during the period (approximately) when the latter is capable of refining it. The separation of the discs 20, 21 when the machine is shut down prevents the discs from rubbing together "dry" while still revolving, and allows the stones 38, 38 to be washed off or removed.

As shown in Figs. I and II, the periphery of the drum 140 has thereon a scale 149 graduated

to indicate the distance apart of the discs 20, 21, by coaction with a stationary index pointer 150, (Fig. XIII). With a suitable choice of gear ratios, $\frac{1}{8}$ in. on the scale 149 can be readily made to correspond to 0.002 in. shift of the rotor 21, permitting very delicate adjustment of the working clearance. This pointer 150 is fast on one end of a spindle 151 mounted in bearings 152 on the casing containing the reduction gear 139. A set screw 153 in an arm 154 fast to the spindle 151 engages the gear case and affords an adjustment of the pointer 150 relative to the drum 140. Angular adjustment of the drum 140 (as above described) to compensate for wear of the stones 38, 38 corrects both the setting of the limit switch 148 and the zero of the drum scale 149.

The pilot motor 133 selected is preferably of such torque characteristic that just as the rotors are brought together to the point of proper clearance, the limit of torque of the motor is reached and it stops itself by overload, and then by time relay the forward circuit is opened.

By this method, the stopping will occur when a definite pressure between discs is reached which corresponds to a definite clearance; and the same clearance will be obtained repeatedly, regardless of wear on stones and of consistency of the raw material to be refined,—for the same raw material.

The torque of the pilot motor must be calibrated to the various materials to be refined. This is accomplished by connecting the motor leads to various taps on the auto-transformer, which changes the torque of the motor due to change in voltage.

It is not the intention, however, to have the pilot motor set the exact clearance gap,—although it may do so,—as there is a hand adjustment provided for precisely setting the gap plus or minus from the setting obtained by the motor.

Disregarding details of electrical control for the time being, the operation of the refiner may be briefly outlined as follows, referring to Figs. I, II, III, VI, VII, IX, XII, XIII, and XIV:

Assume that the refiner has been shut down, that the rotors 20, 21 (or their facing discs 38, 38) are separated about $\frac{1}{2}$ in. and at rest, and that no pulp is being supplied to the head box 110. Under this condition, the pulp supply valve 47 will be turned ninety degrees counter-clockwise from the position shown in Fig. VI, so as to shut-off pulp from the refiner and by-pass it into the pipe 116, and at the same time also vent the refiner into said pipe 116; and the float switch 121, the pressure switch 124, and the pilot motor limit switch 148 will be keeping open the power circuits of the main motors 23, 24, and of the pilot motor 133. If, now, pulp is supplied to the head box 110, it will fill the latter and overflow at 116, and the float switch 121 will cause operation of the main motors 23, 24, and thereby, eventually, close the forward power circuit of the pilot motor 133 after the main motors 23, 24 have about come up to speed. During the last $\frac{1}{8}$ in., say, of the approach of the rotors 20, 21, the intermittent gearing 130, 131 comes into action to turn the valve 47 clockwise ninety degrees, thus turning the pulp supply from the pipe 46 into the pump intake 48 of the refiner. As the rotors 20, 21 come together on the intervening sheet of flowing pulp, the pressure between them rises until the pilot motor 133 reaches its limiting torque and stalls, or the limit switch 148 stops it.

The stoppage of the pilot motor 133 puts the machine in operation with its rotors 20, 21 "dead

set" at the desired working clearance: i. e., the clearance is positively and unyieldingly fixed and held until and unless adjusted. Owing to the assurance that the discs 20, 21 will always run true, without relative deflection of their axes, much smaller working clearances than heretofore are feasible: e. g., as fine as 0.002 in. or 0.001 in. For many kinds of pulp, 900 R. P. M. of the motors 23, 24 and rotors 20, 21 is a favorable speed; but wide variation is admissible.

If, during operation of the refiner, the supply of pulp to the head box 110 should cease or be temporarily interrupted, the float switch 121 will cause the main motor power circuit to be opened and the pilot motor reverse power circuit to be closed, thus stopping the main motors 23, 24 and starting the pilot motor 133 in reverse to separate the rotors 20, 21 and by-pass the pulp from the supply pipe 46 into the pipe 116. As the rotors 20, 21 reach the desired separation of $\frac{1}{2}$ in. (more or less), the pilot motor limit switch 148 will open and stop the pilot motor 133.

Whenever the supply of pulp to the head box 110 is renewed, the float switch 121 will re-start the main motors 23, 24 and bring about the re-starting of the machine, in the manner already described.

If, on failure of the supply of pulp, the float switch 121 fails to act, then the pressure switch 124 will close the reverse power circuit of the pilot motor 133, which will separate the rotors 20, 21 and stop itself by opening the limit switch 148. This switch 148 will also open the main motor circuit and stop the motors 23, 24.

When it is desired to adjust the working clearance between the rotors 20, 21 by hand, as described above, the safety switch 136a is opened, by the mere act of throwing the hand wheel shaft 134a into clutch at 134, as shown in Fig. XIV,—thereby opening both the forward and the reverse power circuits of the pilot motor 133, so that the same cannot be automatically started while the operator is manipulating the shaft 70 by means of the hand wheel 135, as already described. This manual adjustment may be resorted to from time to time whenever (as may usually be the case) the automatic closing together of the discs 38, 38, has not resulted in exactly the desired working clearance,—as determined by samples taken by means of the sampler 98.

In the operation of the refiner, the pulp flows outward between the plane abrasive faces 38, 38 of the oppositely revolving rotors 20, 21, and also through the channels or passages 96 terminating in the innermost grooves 95, which readily take fiber particles or "bundles" that are too large for the clearance between the working faces or discs 38, 38. As the rotors 20, 21 revolve, the innermost grooves 95 of each rotor 20, 21 not only coincide (momentarily) with corresponding grooves 95 of the other rotor, but also partly overlap the grooves 95 of the next set outward (from the center) in the other rotor. During such momentary overlapping, particles in the innermost grooves 95 of each rotor 20, 21 pass into the grooves of the next set outward in the other rotor. In this manner, the larger particles may work their way on outward, from groove to groove back and forth between the rotors 20, 21, until they reach the outermost grooves 95, 95. Or they may work their way outward from groove to groove in other ways to a greater or less extent.

As the rotors revolve, the finer fiber particles or bundles between the plane disc faces 38, 38

are worn down and torn apart by the abrasive action of the discs, and thus still further reduced. The larger particles lodging and travelling outward in the grooves 95, 95 of each rotor rub against the much wider plane abrasive areas between the grooves of the other rotor, and are thus worn down and reduced. Also, such particles held in the grooves 95 of one rotor get pushed out partly into the passing grooves 95 of the other rotor, and are thus split and reduced by the coaction of the discs. The transversely rounded cross section of the grooves 95 tends to push the fibers outward, and this action is assisted by the engagement of fibers in the grooves 95 of one rotor with those in the grooves of the other. The fibers torn off from the larger particles pass out into the gap or clearance between the abrasive disc faces 38, 38 and are there reduced as described above,—and so, likewise, what is left of the originally larger particles, as they become sufficiently reduced to squeeze into the clearance between the plane abrasive surfaces. In the outermost of the grooves 95, the comparatively small quantity of larger particles still surviving remain until they are reduced so as to enter the clearance between the surrounding uninterrupted plane zone, which is shown of substantial width, so as to complete the refining of the last large particles.

The grooves 95 also perform other important functions besides those above mentioned: i. e., they periodically align in a radial direction such fibers as find their way into them, and they prevent the growth of what are known as "rollers" between the flat surfaces 38, 38. These "rollers" consist of bundles of fine fibers rolled together into a cord-like structure which may attain a length of more than an inch and a size (when discharged) of .01 in. or over. By aligning the fibers radially, the grooves 95 prevent them from being pulled apart lengthwise and shortened; while by receiving and holding the rollers as incipiently formed, they cause them to be reduced just like the original larger particles.

It will be seen, therefore, that the efficiency of the disc faces 38, 38 is due to a number of more or less interrelated and coacting features: i. e., the abrasive character of their flat surfaces; the small aggregate area of the grooves 95 in comparison with the total facial area; and the large width of plain surface between adjacent grooves; the shortness of the individual grooves, and their aggregate extension over the greater part of the radial width of the disc, while yet leaving a surrounding plane zone of substantial width; and the fact that the grooves do not afford a direct uninterrupted passage across either disc face, but only an interrupted travel by passage from grooves in one disc to grooves in another during the momentary, periodic overlapping of grooves terminating at different radial distances from the center.

The working clearances of 0.002 in. to 0.001 in. hereinbefore mentioned are comparable to the diameters of the natural ultimate fibers of wood and other paper-making materials,—which ultimate fibers are set free by purely chemical processes of pulp-making, and are about 0.001 in. or less in diameter or thickness. With the abrasive surfaces 38, 38 set to such fine working clearances, therefore, the bundles of fibers in the raw pulp are to a great extent retained in the grooves 95 until the ultimate fibers are parted from one another, since only discrete, individual ultimate fibers and bundles of no more than two or three fibers thick can enter a clearance so small as

0.002 in. Moreover, even stones as truly flat as can be made have slight inequalities which in operation vary the effective clearance, sometimes augmenting it, and sometimes reducing it definitely below the ultimate fiber thickness. Accordingly, a great deal of work is done on individual ultimate fibers, splitting, fraying, or otherwise deforming them, and liberating their fine component fibrillae, so as to produce a fuzzy, stringy, broomed state,—accompanied, however, by a minimum of actual cutting or breaking in two crosswise.

Fig. XIV is a diagram showing the principal parts of the machine as thus far described, (marked with the same reference numerals as in Figs. I–XIII) together with one suitable arrangement of electrical controls and connections. In this diagram, the power circuits and their parts are shown in heavy lines, and the control circuits and their parts in light lines. In the symbols employed, the subscripts 1, 2, indicate parts and features associated with the main motors 23, 24, while the subscript 3 indicates parts and features associated with the pilot motor 133.

AH is a double manual switch device for changing the machine over from manual control to completely automatic control, and vice-versa, and HH is a manual starting and stopping switch for manual control. S₁, S₂ are the starting contactors for the main motor power circuits, and N₁, N₂ the corresponding running contactors, while S₁C, S₂C, N₁C, N₂C are corresponding coils in the main motor control circuit. MS is a time relay switch (delayed opening) to permit starting when the reverse contactor LS₃R of the pilot motor limit switch device 148 is open, and MN is a time relay (delayed opening) for throwing the main motors 23, 24 across the power lines for normal running.

IS, IN, IPF, IPR, IP, IQ are interlock switches or "interlocks" controlled by the corresponding holding coils ISC, INC, IFRC, IPC, IQC in the control circuits, and normally open or closed as shown in Fig. XIV. IN₁ and IN₂ are interlocks controlled by energization of the coils N₁C and N₂C in the main motor control circuits. OL₁, OL₂, OL₃ are thermal overload relay switches in the control circuits.

AT is an autotransformer in the power circuit of the pilot motor 133, shown with a plurality of taps *ta*, *tb*, *tc*, *td* for a purpose to be explained hereinafter. 136a is the self-closing safety cut-out switch (already mentioned) for preventing operation of the pilot motor 133 when the hand wheel 135 is in use. F₃ and R₃ are the pilot motor forward and reverse power circuit contactors, and F₃C and R₃C are corresponding coils in the pilot control circuit. T₃ is a time relay (delayed opening) for cutting off current from the forward (rotor-approaching) circuit of the pilot motor 133 after the latter stops under torque, and T₃C is its operating coil. JFR is a double manual switch device for "jogging" the pilot motor 133 in either direction while the switch is held closed for the direction desired. LS₃F, LS₃R are the contactors of the limit switch device 148 for the forward and reverse control circuits of the pilot motor 133. They are shown as mounted coaxially with the switch lever 147, which has a projection 147a between them, and they are yieldingly drawn together toward or against their contacts by a helical tension spring 148a. However, when the lever 147 is rocked against either contactor LS₃F, LS₃R by the cam 145 of the drum 140 driven by the pilot motor 133 (as above described), the cor-

responding forward or reverse control circuit of the pilot motor is opened.

MQ is a (delayed opening) time relay switch to permit starting when the pressure switch 124 is open owing to absence of pulp from the chamber 48.

The refiner may be put into completely automatic operation as follows:

Suppose the machine to be shut down with all switches, relays, and interlocks in their normal (open or closed) condition shown in Fig. XIV, and that completely automatic operation is desired. The AH switch is thrown to its other position, and a supply of pulp from any suitable source (not shown) is turned into the pipe 109 and head box 110. Float 120 will rise and close contactor or switch 121, energizing starting contactor coils S₁C, S₂C through the devices MC, IN, MN, and closing the starting contactors S₁ and S₂. The motors 23, 24 will start. The time relay MN will in due course "time out" the starting contactors S₁, S₂ and "time in" the running contactors N₁, N₂, and the control circuit current will then flow through the devices MS, IN, MN, N₁C, N₂C, while the motors 23, 24 will run normally.

Energization of coils N₁C, N₂C closes the (normally open) interlocks IN₁, IN₂, completing the control circuit through time relay MQ and (normally closed) interlock IQ and coil IFRC. Energization of coil IFRC closes interlock IPF, completing the forward pilot motor control circuit through the devices OL₃, 136a, IPF, T₃, F₃C, and contactor LS₃F, and closes the forward pilot motor contactors F₃, F₃. Thus the pilot motor 133 starts and runs forward to bring the rotors 20, 21 together. During the last $\frac{1}{8}$ in. (say) of the approach of the rotors 20, 21, the valve 47 is turned 90° clockwise, thus directing the pulp supply from pipe 46 into the refiner intake 48. Thereupon, pressure of the pulp on the diaphragm 125 closes switch 124. Soon after this, the relay MQ times out and closes the control circuit through coil IQC, which is thus energized and opens the (normally closed) interlock IQ. The control current now passes through 124 instead of IQ, and MQ is short circuited, while coil IFRC remains in circuit and energized.

The forward-running pilot motor 133 is stopped by stalling when the pressure between the rotor 20, 21 reaches the value corresponding substantially to the desired (or chosen) working clearance between them. Immediately afterward, the relay T₃ times out and opens the forward control circuit of the pilot motor 133. In case the pilot motor should not be thus stopped for any reason, it will still be stopped by opening of the contact LS₃F by the cam 145,—which thus acts as a "safety" over the relay T₃. However, as the action of this cam 145 can be made very accurate,—since with suitable gearing $\frac{1}{8}$ in. movement of the switch roller 146 will correspond to only 0.001 in. change in the gap or working clearance between the rotors 20, 21. Hence the limit switch 148 may, if desired, be used as the primary means of stopping the pilot motor 133,—the relay T₃ then acting as a "safety" over it.

The pressure between discs 20, 21 (and the torque) under which the pilot motor 133 will stall can be adjusted by using various taps *ta*, *tb*, *tc*, *td* of the autotransformer AT.

Immediately after pilot motor 133 starts forward, cam 145 allows contact LS₃R to close; but the reverse pilot motor control circuit nevertheless remains open, because coil IFRC opens and

holds open the interlock IPR in the reverse circuit.

However, when contactor LS₃R closes, a control circuit is completed through coil ISC, which closes the (normally open) interlock IS. Directly after this, the time relay MS times out, thus energizing coil INC, which opens interlock IN. The control current for the running contactors N₁, N₂ then passes through IS instead of IN, and relay MS is short-circuited.

This leaves the refiner in normal operation, with the main motors 23, 24 running.

For manual control, the switch AH is left (or placed) in the position shown in Fig. XIV, whereupon the refiner can be started by closing the switch HH.

The refiner will shut down automatically as follows:

If the pulp supply to the head box 110 fails, float 120 opens contactor or switch 121. Current no longer flows through coils N₁C and N₂C, and contactors N₁ and N₂ open, shutting down the main motors 23, 24. Interlocks IN₁ and IN₂ open; coil IFRC is deenergized; interlock IPF opens and breaks the forward pilot motor control circuit; and interlock IPR closes. The reverse pilot motor control circuit being thus completed, the pilot motor 133 runs in reverse to separate the rotors 20, 21. During the first 1/8 in. (say) of the rotor-separating motion, the valve 47 is turned 90° counter-clockwise, thus shutting off the pulp supply to the refiner and venting its intake 48 into the pipe 116,—whereupon pressure switch 124 opens.

Pilot motor 133 continues running in reverse until stopped by opening of reverse control contactor LS₃R by cam 145, whereupon coil ISC is deenergized and interlock IS opens. If this fails, the pilot motor 133 will continue to run (and compress the spring 71) until it stalls, after which its thermal overload relay OL₃ will open the pilot motor control circuit and cause the contactors R₃, R₃ to open and stop the pilot motor.

The refiner can always be shut down by shifting switch AH to hand control position (if not already so set) and opening switch HH: this breaks the control circuit and produces exactly the same effect as automatic opening of switch 121.

Pressure switch 124 acts as a "safety" over float switch 121: i. e., if contactor 121 fails to open when the pulp supply fails, switch 124 will nevertheless eventually open,—owing to gradual drop of pressure in the intake 48. Coil IFRC being thus deenergized, the pilot motor 133 is started in reverse and the main motors 23, 24 are stopped, as described above,—just as if contactor 121 had responded properly to the failure of pulp,—and pilot motor 133 is finally stopped as described above.

Overload on any of the motors 23, 24, 133 causes their thermal overload relays OL₁, OL₂, OL₃ to open and stop them. Stopping of either of the main motors 23, 24 by OL₁ or OL₂ deenergizes coil N₁C or N₂C and opens interlock IN₁ or IN₂, deenergizing coil IFRC and starting the pilot motor 133 in reverse to separate the rotors 20, 21, etc., as above described. These thermal overload relays OL₁, OL₂, OL₃ are commonly of a hand reset type, so that after shutting down by overload the machine cannot restart automatically.

When pulp is in the head box 110, the coil IPC is energized and holds open the interlock IP in circuit with the jogging switch device JFR; when the pulp supply is shut off, the coil IPC is

deenergized and the interlock IP closed. Thus jogging of the pilot motor 133 is only possible when pulp is not flowing and the main motors 23, 24 are therefore shut down. This corresponds with the purpose of jogging, which is for paralleling or tramming the rotors 20, 21 and for setting the zero on the scale 149 when the rotors are brought into contact when "dry".

Having thus described our invention, we claim:

1. The combination with a rotary disc refiner, of a head box thereabove for supplying it with pulp, means for supplying pulp to said head box, an overflow from said head box for pulp not taken by the refiner, and means for by-passing pulp from the head box around the refiner.

2. The combination with a rotary disc refiner, of a head box thereabove for supplying it with pulp, means for supplying pulp to said head box, and means for stopping the refiner in response to deficiency of pulp in the head box.

3. The combination with a refiner comprising oppositely revolving discs, and electric motors for driving said discs, of a head box for supplying pulp to the refiner, and means for starting and stopping said motors controlled by the supply of pulp to the head box.

4. The combination with a rotary disc refiner, of a head box thereabove with supply connection to the refiner, means for supplying pulp to said head box, and means for stopping the refiner in response to deficiency of pulp in the head box and by-passing further pulp from said supply connection around the refiner.

5. The combination with a refiner comprising oppositely revolving discs, and electric motors for driving said discs, of means for supplying pulp to the refiner, means for cutting off power from said motors in response to deficiency of pulp, and means to enable said motors to start when no pulp is entering the refiner.

6. The combination with a refiner comprising oppositely revolving discs, and electric motors for driving said discs, of means for supplying pulp to the refiner, a motor for shifting the discs relative to one another, means for cutting off power from said disc motors and causing said shifting motor to separate the discs in response to deficiency of pulp, and independent means for operating said shifting motor in the absence of pulp.

7. A rotary disc refiner comprising means for shifting the discs relative to one another while running, to bring the discs into refining proximity when starting the machine and separate them when shutting it down, means for supplying the machine with pulp to be refined, and means for automatically admitting the pulp into the machine when its discs are brought together and cutting it off therefrom when they are separated.

8. The combination with a refiner comprising oppositely revolving discs, and electric motors for driving said discs, of means for starting said motors, means for shifting the discs relative to one another, and means for automatically admitting pulp to the refiner as the discs approach working proximity.

9. The combination with a refiner comprising oppositely revolving discs, and electric motors for driving said discs, of means for supplying pulp to the refiner, means for cutting off power from said motors in response to deficiency of pulp, and means for separating the discs when power is cut off from said motors.

10. The combination with a refiner comprising oppositely revolving discs, and electric motors for

driving said discs, of means for supplying pulp to the refiner, means for cutting off power from said motors in response to deficiency of pulp, and means for separating the discs when power is cut off, and for shutting off pulp from the refiner as the discs recede from one another.

11. A rotary disc refiner comprising means for shifting the discs relative to one another while running, to bring the discs into refining proximity when starting the machine and separate them when shutting it down, means for supplying the machine with pulp to be refined, and valve means for admitting the pulp into the machine and cutting it off therefrom, and a lost motion connection from said shifting means to said valve means whereby pulp is admitted during the final approach of the discs and shut off during their initial separation.

12. A rotary disc refiner comprising oppositely revolving discs, and means for bringing said discs into refining proximity and fixedly maintaining them a definite distance apart while running, and for positively separating them when the machine is shut down.

13. A rotary disc refiner comprising means for shifting the discs relative to one another while running, to bring the discs into refining proximity when starting the machine and separate them when shutting it down; and a reversible motor for operating said shifting means.

14. A rotary disc refiner comprising oppositely revolving discs, in combination with a motor for shifting the discs relative to one another of such maximum torque as to stall under a pressure between the approaching discs corresponding to their working clearance.

15. A rotary disc refiner comprising oppositely revolving discs, in combination with a motor for shifting the discs relative to one another of such maximum torque as to stall under a pressure between the approaching discs corresponding to their working clearance, and means for varying the maximum torque of the motor over a range corresponding to the desired range of working clearance.

16. The combination with a refiner comprising oppositely revolving discs, and electric motors for driving said discs, of means for starting said motors, means for shifting the discs relative to one another, and means for actuating said shifting means to bring the discs into working proximity after the motors come up to speed.

17. A rotary disc refiner comprising means for shifting the discs relative to one another while running, to bring the discs into refining proximity when starting the machine and separate them when shutting it down; a reversible motor for operating said shifting means; and means for automatically stopping said motor as the discs reach their limits of movement each way.

18. A rotary disc refiner comprising oppositely revolving discs, in combination with a motor for shifting the discs relative to one another to bring them into working proximity, and means for limiting the length of time said motor can run when bringing the discs together.

19. A rotary disc refiner comprising means for shifting the discs relative to one another while running, to bring the discs into refining proximity when starting the machine and separate them when shutting it down; a reversible motor for operating said shifting means; and means for automatically limiting the number of revolutions of said motor both ways and thus controlling the gap between the discs for the

operating and shut down conditions of the refiner.

20. A rotary disc refiner comprising means for shifting the discs relative to one another while running, to bring the discs into refining proximity when starting the machine and separate them when shutting it down; a reversible motor for operating said shifting means, and means for automatically controlling it; manual means for operating said shifting means; and means for rendering said motor inoperative when said manual means is used.

21. A rotary disc refiner comprising means for shifting the discs relative to one another while running, to bring the discs into refining proximity when starting the machine and separate them when shutting it down, and means responsive to absence of pulp for actuating said shifting means to separate the discs.

22. The combination with a refiner comprising oppositely revolving discs, and electric motors for driving said discs, of means for supplying pulp to the refiner, and means for stopping said motors controlled by the pressure of pulp entering the refiner.

23. A rotary disc refiner comprising means for shifting the discs relative to one another while running, to bring the discs into refining proximity when starting the machine and separate them when shutting it down; a reversible motor for operating said shifting means; and a pressure switch actuated by the absence of pulp in the refiner to start the motor and separate its discs.

24. A rotary disc refiner comprising means for shifting the discs relative to one another while running, to bring the discs into refining proximity when starting the machine and separate them when shutting it down; a reversible motor for operating said shifting means; and means for automatically stopping said motor as the discs reach their limits of movement each way, including a rotating part driven by the motor, a switch, and a switch actuator carried by said rotating part and adjustable relative thereto.

25. A rotary disc refiner comprising means for shifting the discs relative to one another while running, to bring the discs into refining proximity when starting the machine and separate them when shutting it down; a reversible motor for operating said shifting means; means for automatically stopping said motor as the discs reach their limits of movement each way, including a rotating part driven by the motor, a switch, and a switch actuator carried by said rotating part and adjustable relative thereto; and means co-operating with said switch actuator to indicate the interval between the discs.

26. A rotary disc refiner comprising means for shifting the discs relative to one another while running, to bring the discs into refining proximity when starting the machine and separate them when shutting it down, and means operated by said disc-shifting means for indicating the interval between the discs.

27. A rotary disc refiner comprising means for shifting the discs relative to one another while running, to bring the discs into refining proximity when starting the machine and separate them when shutting it down, means operated by said disc-shifting means for indicating the interval between the discs, and means for adjusting said indicating means to compensate for wear of the discs.

28. A refiner comprising oppositely revolving discs and drive shafts therefor, one of the discs

having pulp feed passage therethrough into the space between the discs; means for supplying pulp to said feed passage; a pedestal adjacent the other disc having therein a thrust bearing for its shaft, including an externally screw threaded axially shiftable member anti-turningly engaged in the pedestal; a gear nut in said pedestal on said screw threaded member; and means for rotating said nut in said pedestal to shift said bearing and shaft and vary the relative positions of the oppositely revolving discs.

29. A rotary disc refiner comprising oppositely revolving discs, means for bringing said discs into refining proximity and fixedly maintaining them a definite distance apart while running, and for positively separating them so as to pass pulp freely when the machine is shut down, and means for tilting the axis of one disc to true it with the other.

30. A refiner comprising oppositely revolving discs with their drive shafts, thrust bearings for said drive shafts, and means affording a balanced connection between said thrust bearings in the plane of the shafts, so as to take the thrust between the discs as a mere pull, substantially without any tendency toward untruing of the shafts and discs.

31. A refiner comprising oppositely revolving discs with their drive shafts, thrust bearings for said drive shafts, and a casing for said discs affording a balanced connection between said thrust bearings, so as to take the thrust between the discs as a mere pull, substantially without any tendency toward untruing of the shafts and discs.

32. A refiner comprising oppositely revolving discs with their drive shafts, inner thrust bearings for said shafts closely adjacent the discs, means for relatively adjusting said bearings and the discs toward and from one another, outer journal bearings for said shafts, and means for relative adjustment of said outer bearings to true the discs with one another.

33. The combination of a rotary disc refiner with pulp feed passage through a disc into the space between the discs, and a supply passage below said pulp feed passage opening upward thereinto.

34. A rotary disc refiner including a revolving disc with hub and drive shaft, a pulp intake through the hub into the space between the discs, and a pedestal adjacent the hub having therein a thrust bearing for said drive shaft and a pulp supply passage, extending from below the bearing upward between the same and the hub and opening into the hub intake.

35. A rotary disc refiner including a revolving disc with hub and drive shaft, an annular pulp intake through the hub into the space between the discs, curved inclined feed vanes in said annular intake with their concave sides leading, and a pedestal adjacent the hub having therein a bearing for said drive shaft and a pulp supply passage, extending between the bearing and the hub and opening into the hub intake.

36. A rotary disc refiner including a casing enclosing the discs, an annular pulp intake through the hub of one of the discs into the space between the discs, a pedestal adjacent the hub having therein a bearing for said drive shaft and a pulp supply passage, extending from below the bearing upward between the same and the hub and opening into the hub intake, and means forming sealed joints between said hub and pedestal at both sides of said passage and of said annular

intake, including means at the side of said passage adjacent the casing tending to produce flow into the intake, thereby preventing flow the other way.

37. A refiner comprising revolving discs and a casing therefor with discharge for refined pulp, there being an opening through the discharge passage wall, and a sampler insertable in said opening so as to project into the path of the discharging pulp and collect a sample thereof.

38. A refiner comprising revolving discs and a casing therefor with discharge for refined pulp having an inward and downward sloping wall with an opening therethrough, and a vessel insertable in said opening having an inclined inner end adapted to close the opening in one position and to project into the path of the discharging pulp and collect a sample thereof when reversed.

39. A rotary disc refiner comprising oppositely revolving rotors with coating flat abrasive faces each having therein a multiplicity of grooves extending radially thereof, individually short so that fibers cannot traverse the whole radial width of the face in a single groove, and surrounded by an uninterrupted plane zone of substantial radial width coating with a similar zone of the other rotor; the grooves in the two rotors being so related that as the rotors revolve their grooves terminating at different radial distances from the center partially overlap, allowing fiber particles to travel outward by passing from groove to groove until sufficiently reduced to 'squeeze' between the plane abrasive faces of the rotors.

40. A rotary disc refiner comprising oppositely revolving stones with coating plane abrasive faces dead set to a definite fixed working clearance, when adjusted, and provided with means for radially aligning the fibers being refined and preventing the growth of rollers between the flat abrasive refining surfaces.

41. A fiber pulp refiner rotor having a flat abrasive face with a multiplicity of fiber receiving and transmitting grooves extending radially thereof, individually short but in the aggregate extending over the greater part of the radial width, and with an uninterrupted plane facial zone outside the grooved area.

42. A rotary fiber pulp refiner rotor in accordance with claim 41, wherein the radial grooves are of transversely curved section, so that particles in said grooves are forced outward toward the cooperating oppositely moving rotor by contact with its abrasive face or with particles in its grooves.

43. A rotary disc fiber pulp refiner stone having a flat abrasive face with a multiplicity of fiber receiving and transmitting individually short radially extending and overlapping grooves therein, narrower than the intervening plane abrasive areas, and with an uninterrupted plane zone of substantial radial width beyond them.

44. A rotary fiber pulp refiner stone having a central pulp supply cavity and a flat surrounding abrasive face and having tapering supply passages in the stone radiating from said cavity and terminating in radially extending grooves in the stone face, and also having other individually short radially extending fiber receiving and transmitting grooves which, together with the first mentioned grooves, extend in the aggregate over the greater part of the radial width of the stone face, and having an uninterrupted plane facial zone outside the grooved area.

45. A rotary fiber pulp refiner stone having a

- flat acting face and a central pulp supply cavity, and having in its face a multiplicity of series of radially extending fiber receiving and transmitting grooves, each series extending outward from the center on a slope away from the direction of rotation of the stone, and its adjacent grooves overlapping one another circumferentially of the stone.
46. A rotary disc refiner comprising oppositely revolving artificial, homogeneous stones of grade 40—250 and hardness M—Z with coating plane abrasive faces, dead set to a definite, fixed working clearance.
47. A rotary disc refiner comprising oppositely revolving artificial, homogeneous stones of grade 40—250 and hardness M—Z with coating plane abrasive faces, dead set to a definite, fixed working clearance, and having in their working faces radially extending grooves to radially align the fibers being refined and prevent the growth of rollers between the stones.
48. A rotary fiber pulp refiner disc having a flat abrasive face with a multiplicity of radially extending fiber receiving and transmitting refining grooves therein, shorter than the radial width of the abrasive disc face and substantially narrower than the intervening plane abrasive areas.
49. A refiner comprising oppositely revolving discs having flat abrasive faces each with a multiplicity of radially extending grooves therein, substantially narrower than the intervening plane abrasive areas; thrust bearings for maintaining said discs with a dead-set, definite, fixed working clearance between their abrasive faces, corresponding to the fineness of fiber desired in the product; and means for relatively adjusting said bearings and thus changing the dead-set working clearance maintained by them between the abrasive disc faces.
50. A refiner comprising oppositely revolving discs and drive shafts therefor, one of the discs having pulp feed passage therethrough; a casing structure enclosing said discs having thrust bearings for their drive shafts and a pulp supply passage opening into said feed passage of one of them, and also affording discharge passage for the pulp refined between the discs, and having an opening through the discharge passage wall; flat abrasive stone facings for said oppositely revolving discs having central pulp cavities communicating with said disc feed passage, and having in their abrasive faces around said cavities a multiplicity of radially extending grooves substantially narrower than the intervening plane abrasive areas, for radially aligning the pulp fibers and preventing the growth of rollers between the facings; means for adjusting one of said thrust bearings and the corresponding drive shaft and disc axially relative to said casing and the other drive shaft and disc, and thereby dead-setting the coating plane abrasive stone faces to a definite, fixed working clearance corresponding to the fineness of fiber desired in the product; and a sampler insertible in said discharge passage wall opening so as to project inward into the path of the discharging pulp and collect a sample thereof, so that the correctness of the dead-set working clearance between the stone faces may be easily determined.
51. The improvement in mechanically refining an aqueous fiber suspension or pulp which comprises working and deforming its individual ultimate fibers between coating relatively moving abrasive surfaces having an effective clearance approximating and less than the diameter of the ultimate fibers of the pulp, and compelling all the fibers to pass through said clearance before leaving the discs.

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