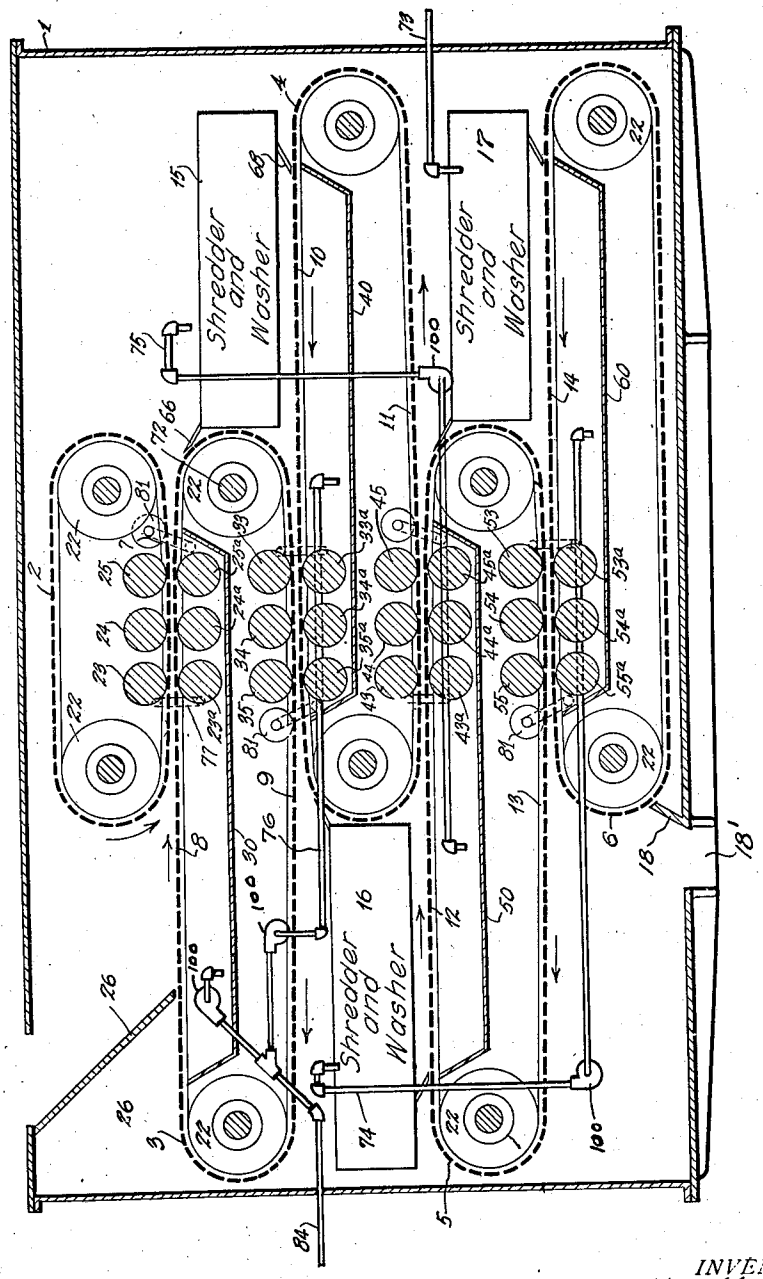
Jan. 13, 1931. O. MANTIUS 1,788,840

APPARATUS FOR WASHING PULP

Filed April 6, 1928 3 Sheets-Sheet 1

Fig. 1



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APPARATUS FOR WASHING PULP

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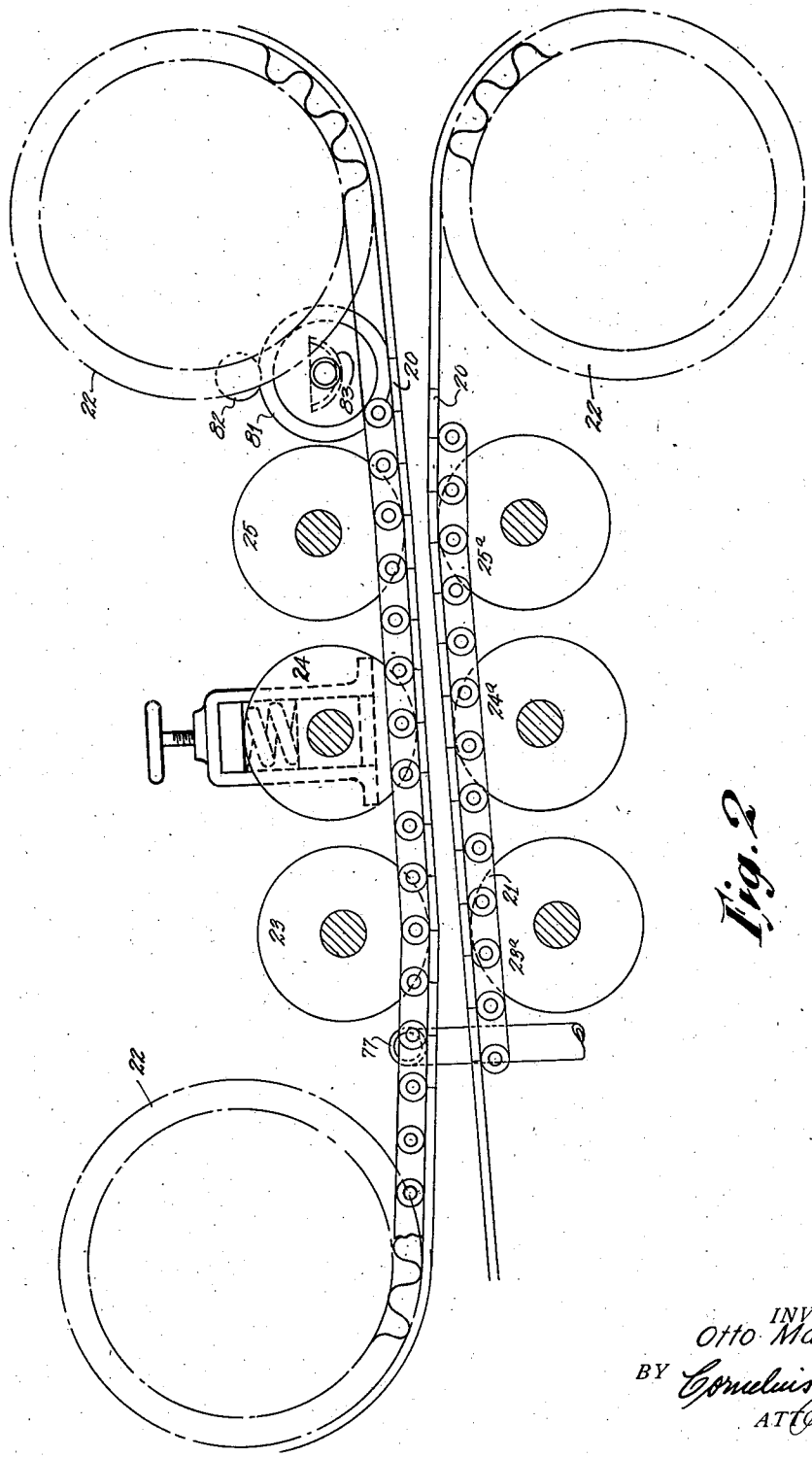


Fig. 2

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APPARATUS FOR WASHING PULP

Filed April 6, 1928 3 Sheets-Sheet 3

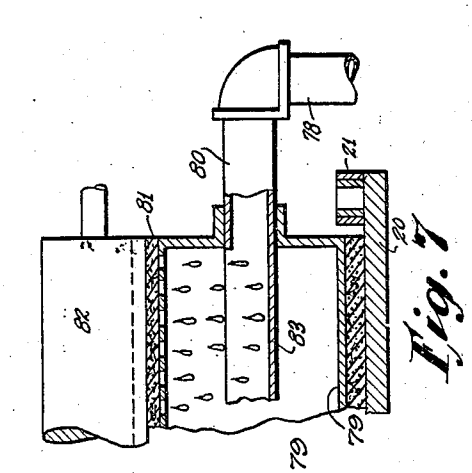


Fig. 7

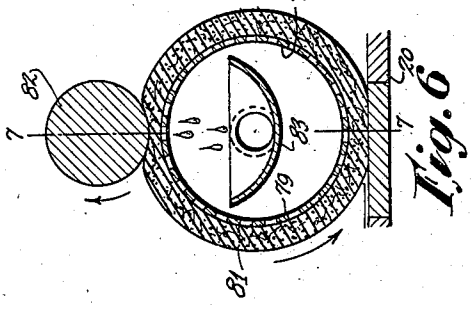


Fig. 6

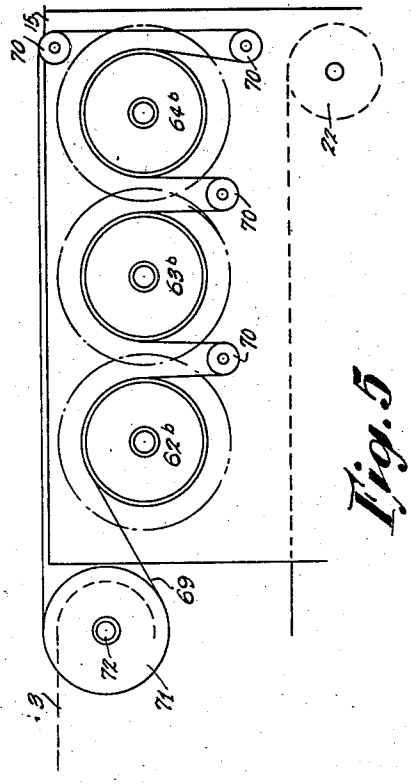


Fig. 5

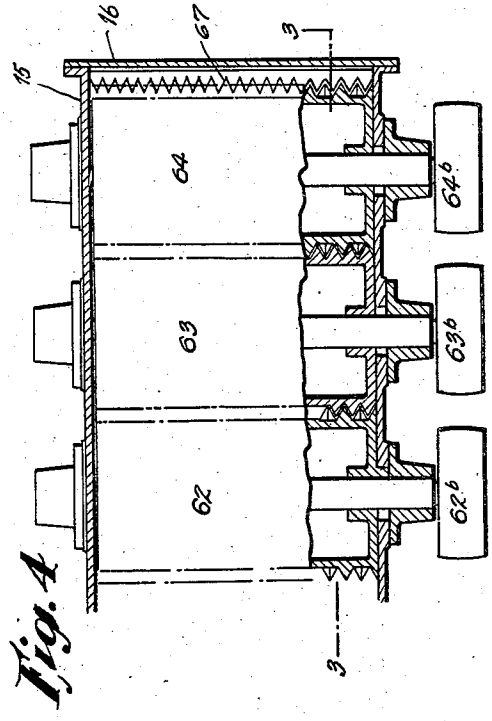


Fig. 4

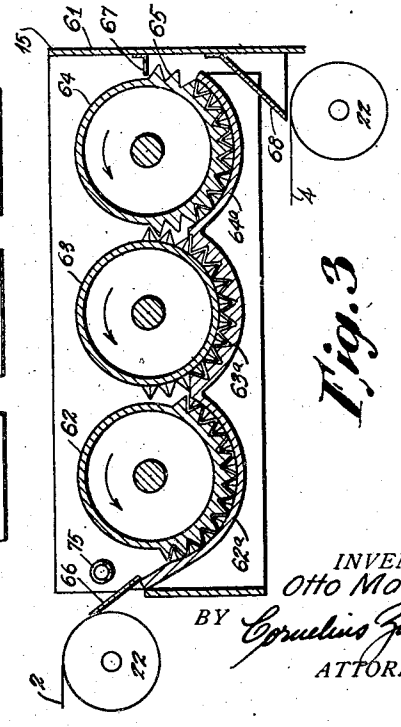


Fig. 3

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UNITED STATES PATENT OFFICE

OTTO MANTIUS, OF NEW YORK, N. Y.

APPARATUS FOR WASHING PULP

Application filed April 6, 1928. Serial No. 267,978.

This invention is an apparatus for removing chemicals from pulp produced by the soda, sulphate or sulphite processes well known to the art.

In the commercial preparation of pulp, it is discharged from the digester with a considerable chemical content which it is desired to remove in order to prepare the pulp for bleaching and to recover the chemical for further use. This removal of the chemical has heretofore been accomplished by placing the pulp in large wash tanks or diffusers and washing out the chemical by causing water to flow through the pulp. Large quantities of water are required in the removal of chemical in this manner and the process is relatively slow. Furthermore, the cost is high due to the quantity of the fresh hot water employed and the relatively large amount of water which must be evaporated in recovering the chemical therefrom.

The purpose of the present invention is to free the pulp of chemical through the employment of a relatively small expenditure of water by the use of simple and efficient mechanical means, whereby the cost of heating the water employed is minimized, and the recovery of the chemicals for further use through steam concentration is accomplished with economy and facility.

Generally speaking, the apparatus of this invention embodies means for passing the pulp through a succession of pressure zones, and between each two consecutive zones, means is provided for thoroughly washing the pulp as it travels along a predetermined path, so that the pulp moves continuously and the operations are in effect continuous operations calculated to produce maximum output of the machine.

In its preferred, practical form, the apparatus of the present invention embodies a plurality of consecutively cooperating conveyors with which are associated pressure rolls cooperating with the respective conveyors to form between them converging mouths through which the pulp to be operated upon is passed by the conveyors in order that the pulp may be subjected to successive compressing operations. Positioned contiguous to the outlet of each pressure mouth is a shredding and washing device, so that the material after being compressed is passed through such device and thoroughly shredded and washed.

The washing operations are carried on with water supplied from any suitable source and the purpose of which is to dilute the chemical contained in the pulp so that when the pulp is subsequently compressed in the next succeeding pressure mouth, the water squeezed out of the pulp by this operation will carry with it a part of the chemical contained in the pulp.

By utilizing a machine having a succession of these pressure mouths with interspersed shredding and washing devices, the material is passed through the machine in a continuous manner being alternately shredded and washed and compressed in order to alternately dilute the chemical contained in the pulp and thereupon squeeze the dilute chemical solution therefrom.

The washwaters used in the successive operations are preferably, though not essentially, employed in preceding washing operations in order to economize in water consumption and to produce, as a product, a fairly strong solution of the chemical which can be readily concentrated for the purpose of recovering the chemical for further use.

The apparatus of this invention constitutes a marked departure from prior practice. It embodies numerous novel features, some of which may be used without employing all. Among these novel features may be mentioned efficient apparatus for removing the water-chemical solution from the upper wall of each tapering mouth. This apparatus consists, generally speaking, in a soft surface

suction roll adapted to absorb the water to be removed from the conveyor and to transport it to a position where it is adapted to be squeezed from the roll and delivered to a suitable duct which conducts it away.

Another important feature of the invention is inherent in a novel form of shredding and washing apparatus which is so constructed as to shred, knead and simultaneously wash the pulp in order to bring about a most intimate contact between the washwater and the fibres of the pulp to the end that the dilution of the chemical may be as great as possible and the pulp divested of its chemical content as expeditiously as possible.

Features of the invention, other than those specified, will be apparent from the hereinafter detailed description and claims, when read in conjunction with the accompanying drawings.

The accompanying drawings illustrate one practical embodiment of the invention, but the construction therein shown is to be understood as illustrative, only, and not as defining the limits of the invention.

Figure 1 is a diagrammatic view of a machine embodying the present invention.

Figure 2 is an enlarged detail elevation showing apparatus forming a part of the structure illustrated in Figure 1, and functioning to press the pulp in order to squeeze the water therefrom.

Figure 3 is a vertical longitudinal section through shredder and washing apparatus shown diagrammatically in Figure 1. This section is taken on the line 3—3 of Figure 4.

Figure 4 is a plan view of the structure shown in Figure 3.

Figure 5 is a side elevation of the same structure showing the manner in which the moving parts are driven.

Figure 6 is a section showing apparatus for removing a portion of the water squeezed out from the material.

Figure 7 is a section on the line 7—7 of Figure 6 showing certain parts in elevation.

The whole apparatus is preferably, though not essentially, mounted within a suitable casing designated in Figure 1 of the drawings by the reference character 1. This casing may be of any suitable form or construction and may, in practice, be the room of a building.

By reference to Figure 1, it will be noted that there are a number of conveyors mounted within this casing, and in this figure, I have shown five of them. They are respectively designated 2, 3, 4, 5 and 6. These conveyors are mounted one above the other and in such relation that they are adapted to cooperate with one another. Thus, the lower reach 7 of the conveyor 2 is positioned to cooperate with the upper reach 8 of the conveyor 3. The lower reach 9 of the conveyor 3 cooperates with the upper reach 10 of the conveyor 4, the lower reach 11 of the conveyor 4 cooperates with the upper reach 12 of the conveyor 5, while the lower reach 13 of the conveyor 5 cooperates with the upper reach 14 of the conveyor 6.

It will be noted, moreover, that the conveyors are positioned in staggered relation, so that each projects a distance beyond the other in order that pulp placed on the conveyor 3 to the left of the conveyor 2 in Figure 1 may be fed by the conveyor 3 between the reaches 7 and 8 to be fed after passing between said conveyors to a shredder or washer 15 positioned beyond the discharge end of the conveyor 3.

This shredder and washer is positioned above the projecting portion of the conveyor 4, so that after the material is passed through the shredder and washer 15, it is fed to the conveyor 4 to be carried thereby between reaches 9 and 10 of the conveyors 3 and 4 and discharged into a second shredder or washer 16 from which it is in turn discharged on to the conveyor 5 to be carried thereby between the reaches 11 and 12 of the conveyors 4 and 5 and thereupon discharged into a third shredder and washer 17, from which it is thereafter discharged on to the lowermost conveyor 6 to be carried thereby between the reaches 13 and 14 and delivered down an incline table 18 through a hole 18′ into a trough by which the material is conveyed away.

All of the conveyors 2—6 are of the same construction and I find it practical to employ slat conveyors, such as shown in Figure 2. Here each conveyor is illustrated as embodying metal slats 20 extending transversely of the direction of travel of the conveyor and for the full width of the machine. These slats are positioned edge to edge and are mounted on sprocket chains 21 by which they are supported and moved. The sprocket chains operate about suitable spacing and driving sprockets 22 as shown and these sprockets are all driven at the same speed so that the conveyors will all travel at uniform speeds.

The cooperating reaches of the several conveyors have associated with them pressure rolls. That is to say, above the lower reach 7 of the uppermost conveyor 2 are positioned a plurality of pressure rolls 23, 24 and 25 and cooperating with the upper reach 8 of the conveyor 3 and positioned directly below the rolls 23, 24 and 25 are cooperating rolls 23*a*, 24*a* and 25*a*. These rolls are positioned to engage with the backs of the slats 20 of the conveyors with which they cooperate and, as shown in Figure 2, said rolls are positioned at progressively decreasing distances apart. Thus, the rolls 23 and 23*a* are positioned slightly further apart than the rolls 24 and 24*a* which in turn are positioned slightly further apart than the

rolls 25 and 25*a*, so that those portions of the conveyors which travel between said rolls form a converging mouth in the direction of travel of the conveyors. The rolls 23, 24 and 25 and the cooperating rolls 23*a*, 24*a* and 25*a* are mounted in suitable bearings, so as to be held firmly in position although the bearings may be spring pressed or weighted as shown in Figure 2 so that if the conveyors meet with abnormal resistance due, e. g., to unyielding foreign matter carried into the converging mouth by the material acted upon, the rolls may slightly retract or be moved apart sufficiently to permit the material to pass through without damaging the apparatus.

Under normal conditions, however, the pressure rolls are mounted so that the cooperating reaches of the conveyors will not move apart, but will subject the material fed between said conveyors to a constantly increasing pressure as it is carried along by and with the conveyors. Thus, if material is fed on to the upper reach of the conveyor 3 down a feed table 26 and is carried by the conveyor into cooperation with the conveyor 2, it will necessarily follow that such material will be carried through the converging pressure mouth formed in the manner described whereby the material will be compressed to a substantially solid cake and during this operation, a large percentage of the water contained in the material will be squeezed out therefrom.

The rollers which I have described are those cooperating with the lower reach of the conveyor 2 and the upper reach of the conveyor 3, but the three sets of rolls associated with the other cooperating reaches of the several conveyors are formed and mounted in the same manner and function for the same purpose as already explained. I refer in this connection to rolls 33, 34 and 35 and their cooperating rolls 33*a*, 34*a* and 35*a*, as well as the rolls 43, 44 and 45 and their cooperating rolls 43*a*, 44*a* and 45*a* and also the rolls 53, 54 and 55 and their cooperating rolls 53*a*, 54*a* and 55*a*. As a matter of fact, the several sets of rolls are pressure rolls and their purpose is to provide sufficient pressure to squeeze out a large proportion of the material presented thereto and to form the material into a substantially solid cake.

During the pressing operations, considerable water is freed from the material and this water is caught by troughs 30, 40 and 50 and 60 which are positioned directly beneath the upper reaches of each of the conveyors 3, 4, 5 and 6.

The shredders and washers of which three are shown in Figure 1 are illustrated more in detail in Figs. 3 to 5 inclusive. All of the washers are of the same construction. Each embodies a suitable tank 61 in which is mounted a plurality of drums 62, 63 and 64, three of which are shown, although a greater or lesser number may be provided. The drums are mounted to rotate on parallel axes in suitable bearings and the bottom of the tank is in the form of arcuate shaped troughs 62*a*, 63*a* and 64*a*. These troughs are curved on radii of which the axes of the respective drums are the centers. The periphery of each drum has formed thereon pyramidal shaped studs 65 and similarly shaped studs are formed on the inner faces of the troughs in such manner that the studs of the respective parts are substantially complementary to one another, but are so placed as to permit rotation of the drums in the troughs and with respect to one another.

The arrangement may be fully appreciated from the showing in Figs. 3 and 4 and it may be stated that there is one less annular row of studs on the trough 62*a* than on the cooperating drum 62. The same relation exists as to the drum 64 and the trough 64*a*, whereas there is one less row of studs on the drum 63 than on the cooperating trough 63*a*. This produces a staggered relation of the parts which permits of rotation. Because of the interfitting of the studs, however, the material passed through the washer is subjected to a shredding and at the same time a kneading action, while the rotation of the drums serves to simultaneously feed the material fed into the tank from the feed table 66 longitudinally through the tank and thoroughly shred and comminute it.

The material is freed from the last drum by a comb 67 having a serrated edge complementary to the studs of said drum and this comb interfits with the studs and combs the fibres free from the drum whereby they are caused to fall on to a discharge plate 68 which delivers them to the next conveyor.

The shredding and kneading drums may be operated by any suitable drive mechanism, but for the purpose of illustration, I have shown the drums as having drive pulleys 62*b*, 63*b* and 64*b* with which a belt 69 is associated. This belt is passed over the several pulleys referred to and around directional and tensioning pulleys 70 and embraces a pulley 71 mounted on the shaft which drives the conveyor 3 so that the several drums are driven from the shaft 72 which drives the conveyor 3, whereby the several drums are driven with the said conveyor.

By reference to Fig. 1, it will be noted that the shredder and washer 17 is supplied with fresh water through a pipe 73. The shredder and washer 16 is supplied from water in the trough 60 through a pipe 74, while the shredder and washer 15 is supplied by water from the tank 50 through a pipe 75. A pipe 76 delivers water from the trough 40 to the outlet pipe 84 which leads to suitable recovery apparatus. Suitable pumping

means, shown as centrifugal pumps 100, is provided for causing the passage of water through these pipes.

The apparatus which I have thus far described is employed in operating upon pulp in the following manner. The pulp is taken as it comes from the digester in a loose semi-solid condition and containing generally about 90 parts of water-chemical solution and 10 parts of pulp, and this semi-solid mass is fed into the apparatus down the table 26 on to the conveyor 3.

The wet semi-solid mass moves along with the conveyor 3 until it is carried thereby into cooperation with the conveyor 2, whereupon both conveyors cooperate to compress the mass and feed it through the tapering mouth between the pressures rolls 23, 23*a*, 24, 24*a*, 25 and 25*a*. During its passage between said rolls, it is subjected to increasing pressures and a large percentage of the water therein is squeezed out so that the material will be delivered from the last cooperating rolls 25 and 25*a* in the form of a relatively solid cake or web. The water which is freed in the manner described carries with it an appreciable part of the chemicals which enter into solution with the water. The water freed from the under side of the material passes through the cracks between the conveyor slats and falls into the trough 30. The water freed from the upper face of the material is squeezed through the cracks between the slats of the upper conveyor on to the upper surface of the lower reach of such conveyor. A part of this water overflows through a by-pass pipe 77 into the trough 30, while the remainder of such water is picked up by the apparatus shown in Figs. 6 and 7 and delivered to the trough 30 through a pipe 78.

The apparatus shown in Figures 6 and 7 embodies a perforated metal cylinder 79 mounted to rotate freely on hollow trunnions 80. The cylinder 79 is covered with absorbent material 81, such as soft felt which as it rolls over the conveyor acts as a blotter to suck up the water. A hard surface roll 82 bears against the felt covering 81 at the top thereof and causes the water to be squeezed out through perforations in the circumference of the cylinder. This water falls into the interior of the cylinder and is caught in a basin 83, which communicates with a hollow trunnion 80. The pipe 78 is connected with a hollow trunnion, so that the water thus gathered is conveyed through the pipe 78 to the trough 30. This apparatus has been found in practice to give unusually satisfactory results, particularly in dealing with hot liquids where a pump would not operate satisfactorily.

Apparatus such as shown in Figures 6 and 7 is associated with each gang of pressure rolls and an overflow pipe 77 also cooperates therewith.

The solid cake or ribbon resulting from the first pressing operation is delivered from the conveyor 3 by way of table 66 to the first shredder and washer 15. This shredder and washer thoroughly shreds the cake or comminutes it while wash-water is fed to the shredder through a pipe 75.

The shredding and washing thus takes place in the presence of further water in order that the chemical within the material may be further diluted. The material is delivered from the shredder and washer 15 in efficiently divided form and in a wet semi-solid condition to the upper reach of the conveyor 10, which serves to carry the material into cooperation with the lower reach of the conveyor 3 and these conveyors collectively pass the material through the second pressing operation to again form the material into a cake and simultaneously squeeze out the water-chemical solution into the trough 40. After leaving the second gang of pressure rolls, the material is delivered to a second shredder and washer 16 supplied with water through the pipe 74 and wherein a second shredding and washing operation with further dilution takes place. The material is delivered from the second shredder and washer on to the upper reach 12 of the conveyor 5 to be carried thereby between the third gang of pressure rolls, which deliver a third cake or web to a third shredder and washer 17 and simultaneously deliver the products of the further dilution to the tank 50.

The shredding and washing operations described are repeated in the apparatus 17 supplied with water through the pipe 73 and the finely divided pulp is thereupon delivered to the conveyor 6 to be passed therewith through the fourth and last pressing operation, the aqueous product of which is received in the trough 60 while the resulting cake or web is fed down the incline table 18 out of the machine.

Particular attention is called to the fact that prior to each compressing operation, a diluent is added and each time the material is subsequently compressed, this diluent is squeezed out, carrying therewith a portion of the chemical previously contained in the pulp. In other words, each time the material is washed and thereafter compressed, it is freed of a further portion of the chemical so that by successive washings and pressings, the material is finally freed of substantially all of its chemical content. In practice, I find it thoroughly practical to feed fresh water through the pipe 73 to the last washer 17, while the washers 16 and 15 are supplied from the troughs 60 and 50, respectively. This constitutes in effect a counter-current washing with the last washing stage utilizing fresh water. This is a highly efficient manner of

treating the material since a relatively small portion of fresh water is required with consequently less water flowing from the trough 30 through the pipe 84 for treatment to recover the chemicals.

Particular stress is placed on the fact that the operation of treating the pulp is continuous, the pulp being in the state of continuous movement from the time it enters until it leaves the machine. Thus, I am able to obtain with a minimum supply of water a thorough washing with maximum speed and output. The pulp which is operated upon by the apparatus shown and described is of a very slippery nature which renders its compression by rolls alone difficult. It is for this reason that the continuous cooperating conveyors are employed in conjunction with the rolls to efficiently feed the pulp through the pressure zones.

Each roll assembly has been illustrated as embodying three sets of cooperating rolls, but a greater or lesser number may be used. Moreover, if desired, I may employ pressure roll assemblies of the character described and claimed in my Patent No. 1,764,456 of June 17, 1930, "Fiber Board Machine", but such apparatus is not essential for the carrying out of the present method, it being particularly desirable here to produce a flushing or circulation of the water through the material so that it will entrain the chemicals and carry them off in solution.

The foregoing detailed description sets forth the invention in its preferred practical form. It will of course be understood, however, that a greater or lesser number of conveyors and washing device may be employed than shown without departing from this invention. For this reason and others, the invention is to be understood as fully commensurate with the appended claims.

The apparatus which I have described is primarily intended for use in the removal of chemicals from pulp, but it may be used for other purposes without departing from this invention.

Having thus fully described the invention, what I claim as new and desire to secure by Letters Patent is:

1. In an apparatus of the character described, pressure means to compress pulp to free the pulp from a quantity of its water content, means to thereupon shred and knead said compressed pulp and thoroughly commingle water therewith, and pressure means to receive the commingled pulp and water, and again compress said pulp to again squeeze the water therefrom.

2. In an apparatus of the character described, means for shredding and kneading pulp and thoroughly commingling water therewith, means for compressing the pulp prior to feeding it to the shredding means, and means for again compressing the pulp to squeeze the water therefrom after it has been shredded and commingled with such water.

3. In an apparatus of the character described, means for squeezing water from pulp and simultaneously forming the pulp into a web, means for shredding and kneading the web and for commingling water with the material thereof for the purpose of diluting the chemical contained in such material, and means for thereafter squeezing such water out of the pulp to remove a portion of the chemical therewith and for simultaneously again forming the pulp into a web.

4. In an apparatus of the character described, a pair of cooperating conveyors positioned with one reach of each in spaced apart relation to one reach of the other, rollers positioned back of the cooperating reaches of said conveyors and coacting therewith to form between said cooperating reaches a compression mouth, means for actuating the conveyors to convey pulp through said mouth for the purpose of squeezing water out of the pulp and forming said pulp into a web, means positioned contiguous to the outlet of said mouth to finely divide the web and mix water with the material thereof, and means for thereafter compressing said mixture of water and material to squeeze the water from the material and again form the material into a web.

5. In an apparatus of the character described, a pair of cooperating conveyors positioned in superimposed relation with one reach of each in spaced apart relation to one reach of the other, rollers positioned back of the cooperating reaches of said conveyors and coacting therewith to form between said cooperating reaches a compression mouth, means for actuating the conveyors to convey pulp through said mouth for the purpose of squeezing water out of the pulp and forming said pulp into a web, means positioned contiguous to the outlet of said mouth to finely divide the web and mix water with the material thereof, and a third conveyor positioned subjacent to and cooperating with one of the first mentioned conveyors, rollers coacting with cooperating reaches of these two latter conveyors to form between adjacent reaches thereof a second pressure mouth through which the mixture of material and water is fed for the purpose of squeezing out the water from such material and simultaneously forming the material again into a web.

6. In an apparatus of the character described, a plurality of superimposed conveyors positioned consecutively in staggered partially overlapped relation to form between contiguous reaches of the several conveyors pressure mouths adapted to compress pulp fed by the respective conveyors through said mouths, rollers positioned back of and engaging with the contiguous reaches of the con-

veyors at the mouths to subject the pulp to pressure while passing through the mouths, and means for thoroughly wetting the pulp prior to its passage through each mouth, whereby the water thus introduced serves to dilute the chemical in the pulp and cause the water-chemical solution to be squeezed from the pulp as the pulp is carried through the pressure mouths of the conveyors for the purpose of freeing the pulp from its chemical content.

7. In an apparatus of the character described, a plurality of superimposed, endless conveyors having openings therein for the passage of liquid therethrough and positioned consecutively in staggered partially overlapped relation to form between contiguous reaches of the several conveyors pressure mouths adapted to compress pulp fed by the respective conveyors through said mouths, rollers positioned back of and engaging with the contiguous reaches of the conveyors at the mouths to subject the pulp to pressure while passing through the mouths, means for thoroughly wetting the pulp after its passage through one mouth and prior to its passage through the next mouth, whereby the water thus introduced serves to dilute the chemical in the pulp and cause the water-chemical solution to be squeezed from the pulp as the pulp is fed through the pressure mouths for the purpose of freeing the pulp from its chemical content, and a suitable receptacle positioned to catch the water freed from the pulp at each compressing operation.

8. In an apparatus of the character described, a plurality of superimposed, endless slatted conveyors positioned consecutively in staggered partially overlapped relation to form between contiguous reaches of the several conveyors pressure mouths adapted to compress pulp fed by the respective conveyors through said mouths, rollers cooperating with the conveyors at the mouths to subject the pulp to pressure while passing through the mouths, shredding and washing means positioned between the outlet of each mouth and the inlet of the next mouth to receive the material discharged from each mouth and to shred it and thoroughly admix it with water before delivering such material to the next mouth.

9. In an apparatus of the character described, a plurality of superimposed, endless conveyors having openings therein for the passage of liquid therethrough and positioned consecutively in staggered partially overlapped relation to form between contiguous reaches of the several conveyors pressure mouths adapted to compress pulp fed by the respective conveyors through said mouths, rollers cooperating with the conveyors at the mouths to subject the pulp to pressure while passing through the mouths, shredding and washing means positioned between the outlet of each mouth and the inlet of the next mouth to receive the material discharged from each mouth and to shred it and thoroughly admix it with water before delivering such material to the next mouth, said shredding and washing means comprising a plurality of toothed rolls positioned within a suitable tank adapted to contain water, and means to revolve said rolls to produce upon the material a combination shredding and kneading action to bring about a thorough admixture of the water with the pulp.

10. In an apparatus of the character described, a plurality of conveyors positioned consecutively in staggered partially overlapped relation to form between contiguous reaches of the several conveyors pressure mouths adapted to compress pulp fed by the respective conveyors through said mouths, rollers cooperating with the conveyors at the mouths to subject the pulp to pressure while passing through the mouths, shredding and washing means positioned between the outlet of each mouth and the inlet of the next mouth to receive the material discharged from each mouth to shred it and thoroughly admix it with water before delivering such material to the next mouth, said shredding and washing means comprising a plurality of toothed rolls positioned within a suitable tank adapted to contain water, and provided with teeth projecting beneath the teeth of the rolls, and means for rotating the rolls to shred and knead the pulp between the cooperating teeth of the rollers and tank and to form a thorough mixture of the water and the shredded pulp.

11. In an apparatus of the character described, a pair of cooperating endless conveyors provided with openings through which liquid may pass and positioned with one reach of each in spaced relation to one reach of the other, rollers positioned back of each of said cooperating reaches of the conveyors and coacting therewith to form between said reaches a compression mouth through which material is adapted to be fed to squeeze liquid from the material and cause it to flow through the openings of the conveyors to the back surfaces of said conveyors, and means for removing such liquid from the back surface of one of the conveyors, said means embodying a perforated cylinder having relatively soft absorbent covering adapted to bear against the conveyor and suck up water therefrom, a roll bearing against said absorbent covering for squeezing the liquid from said covering through the perforations in the cylinder whereby the liquid is introduced into the interior of the cylinder, and a basin positioned within the cylinder to receive such liquid, said basin being provided with a suitable outlet for the discharge of the liquid received by the basin.

12. In an apparatus of the character de-

scribed, a pair of cooperating conveyors positioned with one reach of each in spaced apart converging relation to one reach of the other, means supporting and guiding said reaches to form between said reaches a converging compression mouth through which material is adapted to be fed to squeeze liquid therefrom, and means positioned in advance of the compression mouth to shred and wash pulp and deliver it to one of the conveyors in advance of the compression mouth.

In testimony whereof I have signed the foregoing specification.

OTTO MANTIUS.