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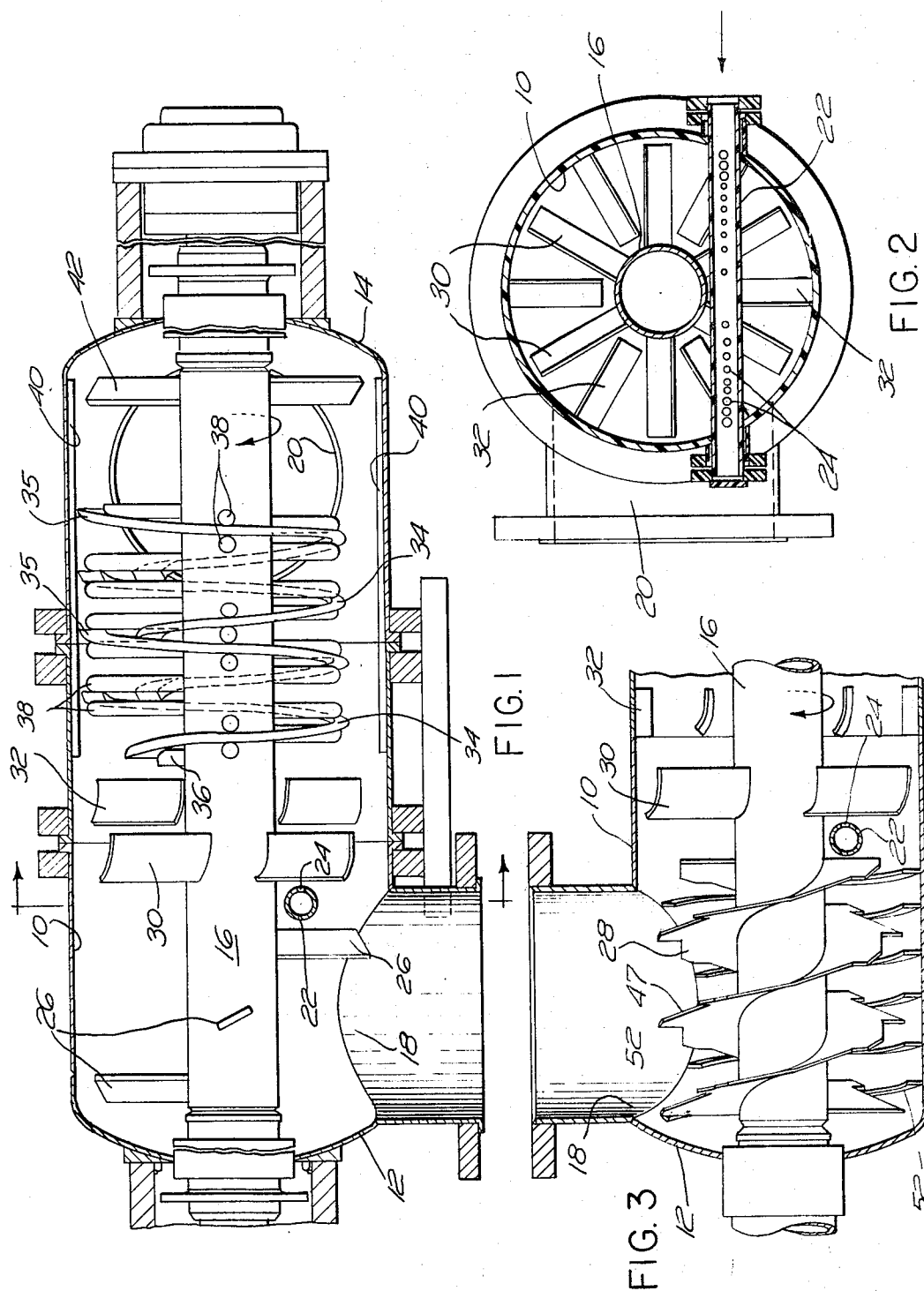
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HIGH DENSITY PULP MIXING

Filed March 27, 1963

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

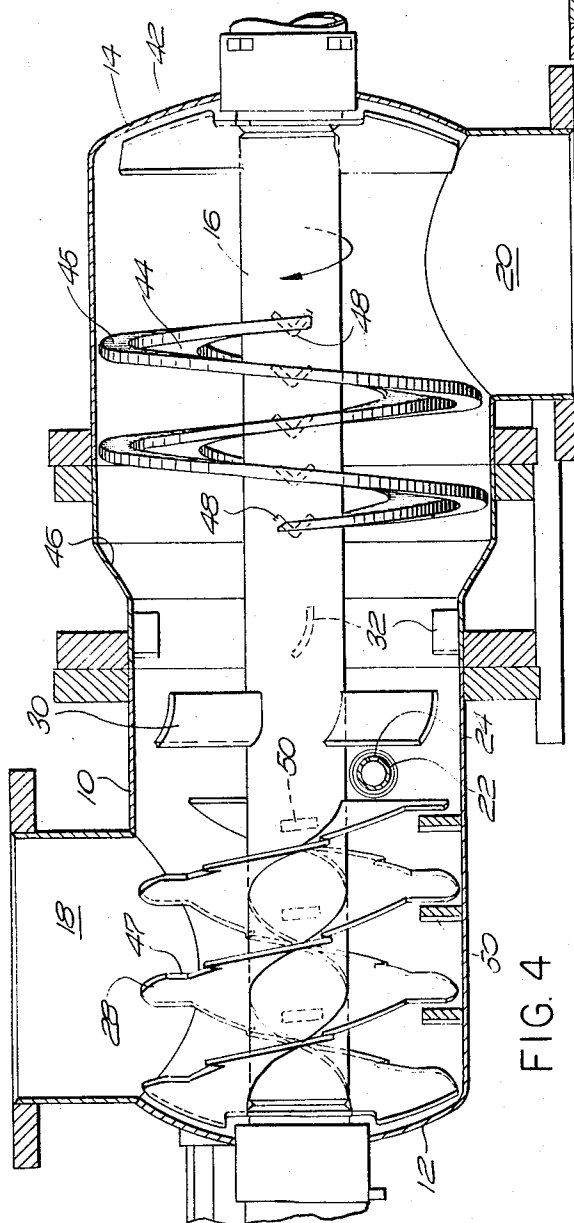


FIG. 4

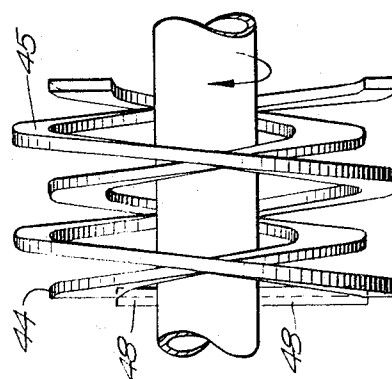


FIG. 4a

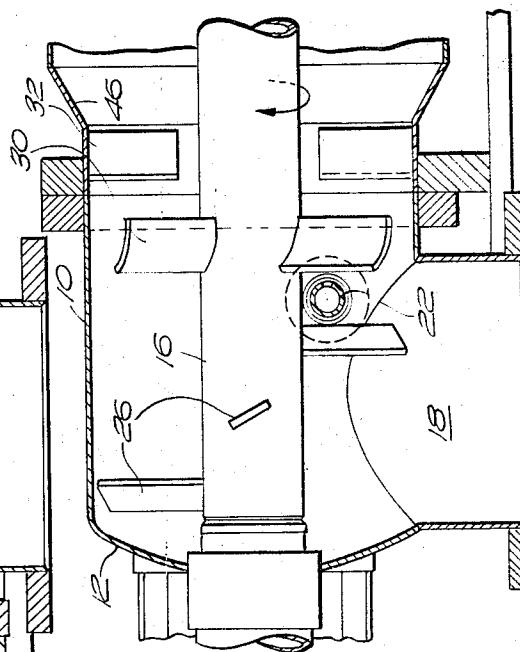


FIG. 5

1

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HIGH DENSITY PULP MIXING

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This invention relates to the mixing of liquids with wood pulp, cellulose or the like and more particularly to the mixing of high concentrations or densities of pulp and liquid bleaching chemicals in a continuous flow fashion as distinguished from batch mixing processes.

When mixing bleaching chemicals or other such liquids into pulps of comparatively high densities in a continuous fashion it has been found that the usual screw impellers or rotary mixing blades tend to cut through the pulp and distribute the chemicals in streaks or pockets. The manner of introducing the liquid chemicals to the pulp emphasizes the problem. This requires that the process be conducted slowly in order to give the liquid time to penetrate throughout the moving pulp, thus delaying the entire process. In mixers of known design, an increase of speed of operation simply means that at a later stage further mixing action must be imposed on the pulp or a delay must be allowed in the process to give the chemicals opportunity or time to disperse and diffuse evenly throughout the mix.

One object of the present invention is to provide equipment and a method for the continuous mixing of liquid chemicals with high density pulp at faster rates than heretofore, so that the time of the process may be shortened. A further object is to provide equipment in which the high speed mixing of liquids in high density pulps may be carried out in such a fashion that the injected liquids are distributed evenly and diffused thoroughly throughout the pulp before the pulp is further processed.

These and other objects are met, according to preferred embodiments of the invention, by providing a mixing chamber in the general form of a hollow cylinder with a rotary impeller shaft mounted axially therein. The pulp enters near one end of the cylinder and it is fed forward or longitudinally initially therein, by outside pressure or by a conveyor on the impeller shaft, past a liquid injector which introduces the chemicals in a transverse line extending across substantially the entire width or diameter of the cylinder. At this point, vanes on the impeller shaft gradually impose a rapidly rotating motion to the pulp in addition to the longitudinal feeding motion so that as the chemicals are injected into the pulp a continuous multiple-layer "sandwich" of pulp layers separated by layers of chemical is produced. Immediately following this area, fixed vanes or guides are provided in the mixing chamber for slowing and stopping the rotational motion of the pulp and again guiding it in forward longitudinal direction. The effect of these fixed vanes is to give a random reorientation of the successive layers of pulp and chemical by the breaking up or collapsing and crumbling of the "sandwich" layers. The vanes for rotating the pulp and for stopping rotation are so arranged that their net ability to convey the pulp forward longitudinally is less than the conveying ability of the initial pulp feeding means, thus insuring that the mixing chamber is always full of pulp in the zone of chemical addition so that the chemical is applied uniformly. Thereafter the broken layers of pulp, with the liquid entrained therein, are manipulated by helical ribbon-like elements on the impeller shaft which knead or work the pulp back and forth in reversals of direction both radially and longitudinally within the

2

cylindrical mixing chamber, thus thoroughly diffusing the chemicals, and the mix is finally discharged near the other end of the cylinder.

Other objects and further details of that which is believed to be novel and included in this invention will be clear from the following description and claims, taken with the accompanying drawings in which are illustrated examples of mixers embodying the present invention and incorporating features described generally above.

In the drawings:

FIG. 1 is a vertical sectional view taken longitudinally through a pressure-fed mixing apparatus according to one form of the invention;

FIG. 2 is a vertical sectional view transversely of the mixing apparatus of FIG. 1 substantially on the line and in the direction of the arrows II-II thereof;

FIG. 3 is a vertical section longitudinally through the inlet end of a mixing apparatus modified for gravity feed of pulp according to another form of the invention;

FIG. 4 is a vertical section lengthwise through another gravity-fed mixing apparatus according to a further form of the invention;

FIG. 4a is a plan view of pulp kneading elements according to FIG. 4, rotated 90 degrees from their position as shown in FIG. 4, and

FIG. 5 is a vertical sectional view through one end of a pressure-fed mixing apparatus modified according to still another form of the invention.

In carrying out the objects of this invention, in the various embodiments here illustrated, a mixing chamber is provided in the form of a hollow cylinder 10 closed at its ends 12 and 14 and carrying a rotatable impeller shaft 16 which extends centrally and axially through the entire chamber. Near one end of the mixing chamber an inlet opening 18 is provided and a suitable outlet opening 20 is located near the other end. In the pressure-fed forms shown in FIGS. 1 and 5, the inlet 18 is conveniently arranged below the cylinder and the outlet 20 at one side or on top of the mixing chamber. In the gravity-fed forms illustrated in FIGS. 3 and 4, it is preferred that the inlet for the pulp enters the top of the chamber at one end while the outlet is at the bottom of the other end of the chamber. In the pressure-fed forms of mixing apparatus an external thick stock pump of known design (not shown) introduces pulp under pressure through the inlet 18 and forces it through the mixing chamber and out of the outlet 20, often under a back-pressure at the outlet. In gravity-fed forms of the mixing apparatus, helical feeding or conveyor screws 28, carried by the impeller shaft within the chamber, impart the desired longitudinal forward motion and pressure of the pulp from the inlet 18 to the outlet 20, where the mix is discharged to atmospheric pressure. Depending upon the type of installation, either the external thick stock pump or the internal conveyor screw serves as the primary or initial feeding or impelling means for the pulp and causes the pulp to move longitudinally in the chamber, under pressure.

In all forms of the invention shown, the liquid, for example, bleaching chemicals, is introduced through a transversely arranged inlet pipe 22 having a series of liquid feeding inlet openings 24 therein facing in a direction downstream, considering the progress of pulp through the mixing chamber. The series of chemical inlet openings constitutes in effect a transverse line extending chordally of the cylinder near the impeller shaft and approaches a full diameter of the chamber. It will be noted that the side of the pipe having the liquid feeding openings therein is opposite the downstream extremity of the pulp inlet opening 18, the impeller shaft in the forms of FIGS. 1 and 5 carrying one or more radially extending

pitched or slanted blades 26 thereon opposite the pulp inlet opening to help direct the pulp under pressure from the inlet longitudinally of the chamber. In the gravity feed forms of FIGS. 3 and 4, the helical conveyor screws 28 provide the necessary feeding pressure as well as longitudinal movement as above described. The choice of equipment used depends upon the consistency of the pulp, the pressure desired within the system including the mixer, and other factors only indirectly related to the mixing operation which follows the introduction of the bleaching or other chemicals.

As the pulp is fed longitudinally through the chamber past the transverse chemical inlet pipe 22, a suitable liquid is introduced through the line of liquid feeding inlet openings at a rate and under pressure sufficient to provide the desired chemical action for the quantity and type of pulp passing through the mixer. Suitable pressure, volume, speed and other controls of known types may be provided for optimum results. In all forms of the invention it is preferred that, just beyond the liquid inlet pipe a plurality of concavely curved radially extending pulp rotating and spreading vanes 30 are mounted on the rotating shaft 16 to rotate in a plane transverse to the mixing cylinder. These rotating vanes pick up the pulp in front of the liquid inlet and cause the mass of pulp to rotate at the same angular velocity as the vanes themselves. At the same time, the primary impelling means, either screw conveyor or external pump, is causing the pulp to move longitudinally in the chamber. This combination of rotary and longitudinal movement of the pulp mass in effect causes the chemical to be sprayed or spread onto surfaces of a succession of discs of pulp. For example, if the pulp is moved longitudinally through the chamber at a forward velocity of three hundred inches per minute, and is rotating at three hundred revolutions per minute, these discs are each one half inch thick. That is, the mass as it leaves the area of chemical application consists essentially of one half inch thick discs of pulp with a layer of chemical between each two successive discs. Obviously, these discs are in reality turns of a helix of pulp and are inclined at a slight angle from a plane normal to the mixer's longitudinal axis. The rotating blades or vanes are curved in such a direction that their leading edges face forwardly in the direction of rotation. Their curvature is for the dual purpose of gradually accelerating the pulp to full rotational velocity and impelling it forward longitudinally, thus conserving power which might be lost if the vanes were not curved.

Just downstream, beyond the trailing edges of these vanes 30, are a series of fixed reversely curved blades or vanes 32, extending from the inner wall of the mixing chamber radially inwardly toward the impeller shaft. In the forms of mixer shown in FIGS. 3 and 4 the vanes 32 are rather short, while in the forms of FIGS. 1 and 5 these vanes extend radially inwardly to points quite close to the impeller shaft as seen in FIG. 2. In either case the function of these stationary reversely curved vanes is to gradually decelerate and check the rotational motion of the pulp and convert rotational motion of the pulp into longitudinal motion. Both the rotating and stationary curved vanes are so arranged that their net ability to convey the pulp forward longitudinally is less than the conveying ability of the initial or primary screw conveyor or pump feed. This insures that the mixing chamber is always full of pulp in the zone of chemical addition so that the chemical is applied uniformly, in the absence of voids at this point. Six of the vanes 30 and six of the vanes 32 are shown in FIG. 2, but more or less may be provided as experience may dictate, for any particular mixing situation. The effect of the stopping of pulp rotation by the rotation-impeding vanes 32 is to break up or collapse and crumble the "sandwich" discs and give a random reorientation of the previously described successive layers of pulp and chemical. This spreads or distributes the liquid in the pulp.

As the pulp leaves the stationary curved vanes it continues to be moved forward longitudinally by the primary or initial pressure and feeding means and it then enters a kneading zone where complete dispersion or fine mixing is performed to diffuse the bleach and make the moving mass more nearly homogeneous. For this purpose the impeller shaft is provided with at least two opposite hand helical ribbon-like kneading blades, shown as the elements 34 and 35 in FIG. 1 and as elements 44 and 45 of different design in FIG. 4. In either form, the action of the helical kneading ribbons is to combine reversals of direction of the pulp both radially and longitudinally within the chamber so that there is a rapid and intimate distribution and intermingling of chemical and pulp throughout the entire mass.

In the form of kneading zone shown in FIG. 1 the first of the helical blades 34 rotates just downstream of the fixed vanes 32. Helix 34 is a spiral, the beginning of the spiral being located close to the impeller shaft and the other end of the spiral being located close to the inner walls of the chamber 10. This tapered spiral form of blade works or turns a curved strip of the mix progressively both radially and longitudinally of the mixing chamber as the impeller shaft is rotated. This tapered spiral extends throughout an arc of substantially three hundred and sixty degrees of the circumference of the cylinder, with one end of the blade mounted or supported directly on or next to the surface of the impeller shaft as by a block 36, the other end and intermediate portions of this blade being mounted between pairs of radially extending supporting posts 38 suitably secured to the impeller shaft. The direction of twist of this first kneading spiral helix is such as to assist the pulp toward the outlet as the shaft 16 is rotated. Immediately following the first helical blade 34 in this form a second reversely helical spiral kneading blade is mounted, this blade being given the number 35. Because this helix is of opposite "hand" or direction from the first kneading blade, the pulp mixture is subjected to a reversal of kneading action in a longitudinal direction backward in the cylinder, further dispersing the chemicals in the mix as it is worked or turned. Note that this second kneading blade is also tapered, that is, it extends spirally at one end close to the impeller shaft and at the other end close to the inner walls of the mixing chamber so that radial as well as longitudinal action is obtained. Although but one pair of reversely pitched kneading helices might be sufficient, FIG. 1 indicates that as many of such blades as are required may be provided, each one after the first being of opposite hand or direction from the preceding kneading blade to produce a series of reversals of the kneading action.

In the modified form of mixer shown in FIG. 4 the kneading zone again has a set of helical ribbon-like kneading blades of opposite hand, but instead of following one another along the longitudinal axis of the mixing chamber the helical kneading blades 44 and 45 of FIG. 4 are arranged concentrically of each other along the same span of the impeller shaft. Radially extending posts 48 on the impeller shaft may support both the inner helix 44 and the outer blade 45. The inner helix 44 is so constructed as to exert a longitudinal impelling force toward the discharge end of the chamber which is somewhat greater than the primary impelling force of the screw conveyor or pump initially feeding pulp through the chamber. The outer helix 45 is arranged to impel the pulp back toward the inlet end of the mixing chamber at approximately half the rate at which the inner helix conveys toward the discharging end. This results in a kneading action as follows: as the inner helix tends to move the pulp longitudinally toward the discharge end at a higher rate than it is being supplied, voids are created immediately behind the turns of the helix. These voids are being filled continuously by pulp folding around the blade from leading edge to trailing edge and by pulp migrating radially inwardly from the outer helix to the inner helix. As the outer helix

attempts to convey pulp in a longitudinal direction opposite to the main stream, the forces opposing this action cause some of the pulp to fold around this helix and also migrate radially outwardly from the inner helix to fill voids behind this blade. This combination of reversals of direction, both radial and longitudinal, results in an intimate intermingling of chemical and pulp with the product emerging from the kneading zone as a homogeneous mass of pulp thoroughly and uniformly impregnated with chemical.

As can be seen, the two opposite hand helical ribbon kneading blades may either be concentrically mounted in the same longitudinal space or be mounted downstream one from the other and still cause the same sort of reversals in both radial and longitudinal directions of movement of the pulp, thus kneading the chemical evenly into all parts of the pulp within a short span of time and within a small area of overall travel of the pulp. Ultimately, pulp will be forced out of the kneading zone by the overriding primary longitudinal feed.

In order to prevent an undesirable amount of gross rotation of the pulp mix within the mixing chamber in those portions of the chamber where rotary motion of the pulp is not needed, longitudinal guiding ribs 40 may be provided on the walls of the cylinder to retard or impede rotation of the pulp mass as a whole.

In the form of FIG. 4, where opposite hand kneading ribbons are mounted concentrically in the same longitudinal space within the chamber, the outer walls on the mixer may be sloped gradually outwardly in downstream direction from the inlet end toward the discharge end as indicated by the slanted or tapering walls 46. This taper is next to the upstream end of the outer helix 45 which is directing pulp back toward the inlet end of the chamber. The tapered walls at this point will guide the pulp moving along the outer periphery in upstream direction, directing it radially inwardly back into the main stream, moving in the opposite direction, without jamming.

In gravity-fed mixing equipment the conveyor screw 28 of FIGS. 3 and 4 may tend to produce rotation of the pulp which might nullify the necessary forward motion and pressure of pulp toward the curved rotating vanes 30. Therefore, in these forms of the invention the flights of the screw 28 work opposite fixed antirotation elements secured to the walls of the chamber, these elements taking the form of separate circumferentially and longitudinally spaced short straight antirotation vanes 50 as shown in FIG. 4 or continuous helical antirotation rifling ribs 52 as shown in FIG. 3. In FIG. 4, notches 47 in screw 28 and the antirotation vanes 50 are so positioned with relation to each other that the conveyor screw 28 can be rotated without interference by or with these fixed antirotation elements. In this form, the notches in the screw flights not only clear the antirotation vanes but also assist in grabbing and carrying away gravity-fed unshredded pulp which may tend to bridge over the chamber inlet opening. Similar notches 47 in edges of screw flights 28 in the form of FIG. 3 serve this same purpose although the screw conveyor clears the rifling ribs 52. The rifling ribs may be preferred over the short antirotation vanes because such rifling may be used to cause or permit a predetermined angular or rotational velocity governed by the pitch of the rifling in relation to the rate of pulp flowing through the chamber. This may increase the time during which the pulp is accelerated from zero angular velocity to the full angular velocity of the rotating curved vanes 30, thus reducing the power required to accomplish this acceleration. In addition to this, in the absence of other means for accomplishing the same result, this spiral rifling retards longitudinal feed just enough to insure that the casing will always be completely full of pulp at the point of chemical addition.

The series of helical kneading blades extends at least to the outlet opening 20, and spaced therefrom, positioned near the end wall 14 beyond the outlet opening, is a set

of slanted or pitched pulp discharge blades 42 mounted on the impeller shaft. These direct the mixed pulp away from the end wall and through the outlet. Obviously, the slant or pitch of the blades 42 is such as to move pulp in a reverse direction from that of the main flow of pulp through the mixing chamber so that pulp in the discharge end of the chamber is being continuously scavenged. Other arrangements might be used to prevent stagnation or pocketing of the mixed pulp near the outlet end of the mixing chamber and help discharge it through the outlet.

Each one of the forms of the invention described above will perform the steps of: first, compacting and moving the pulp mass longitudinally in a cylindrical mixing chamber; second, applying bleaching chemicals or other liquids across a chordal line which approaches a diameter of the mixing chamber while changing the principal direction of movement of the pulp from longitudinal to rotational so as to form successive layers of pulp and chemical; third, collapsing and crumbling of the successive layers by stopping the rotational motion and; fourth, kneading the chemical into the pulp by continuously reversing both radial and longitudinal direction of pulp movement. The introduction of the bleaching chemicals or other liquids across an approximate diameter of the mixing chamber causes a quick and wide-spread distribution of the liquid agents which is not possible with single inlets arranged in the top, bottom or sides of the mixing chamber. The rapid rotation of the pulp while the liquid is being injected, followed by the checking of the rotational motion of the pulp, insures an initial uniformity of distribution of chemicals transversely of the chamber which is not equalled by other arrangements. The final kneading operation, moving the mass and working or turning it both longitudinally and radially of the chamber first in one direction and then in a reverse direction, completes the mix and diffuses the chemicals within a substantially shorter time and space than is customary. As intimated above, the impeller shaft may be rotated at about three hundred revolutions per minute in a mixer according to the present invention. This is about twenty-five percent faster than the usual driving speeds for impeller shafts in mixers of a more conventional nature.

As will be evident from the foregoing description, certain aspects of this invention are not limited to the particular details set forth as examples, and it is contemplated that various and other modifications and applications of the invention will occur to those skilled in the art. It is therefore intended that the appended claims shall cover such modifications and applications as do not depart from the true spirit and scope of the invention.

What is claimed as new and is desired to be secured by Letters Patent of the United States is:

1. Apparatus for mixing a liquid with a pulp mass comprising,

a longitudinally extending cylindrical mixing chamber having

a pulp inlet opening near one end and

a pulp outlet opening near the other end,

means for feeding pulp longitudinally under pressure from said inlet through said chamber to said outlet,

a liquid inlet pipe extending transversely of said chamber near the axis thereof and having a series of liquid inlet openings therein for injecting liquid into pulp in a downstream direction across a transverse line approaching a diameter of said cylindrical chamber,

rotary means adjacent said liquid inlet openings rotating the pulp across a plane transverse of said chamber for spreading injected liquid in transverse layers within the pulp while pulp is fed longitudinally in said chamber,

sets of helical kneading blades downstream of said rotary means extending longitudinally of said chamber and rotatable therein to turn and knead the pulp

with entrained liquid therein radially both inwardly and outwardly and longitudinally of said chamber both toward and away from said pulp outlet end and

means beyond said kneading blades for discharging 5
mixed liquid and pulp from said pulp outlet opening.

2. Apparatus for mixing and thoroughly dispersing a liquid in a pulp mass comprising,

a longitudinally extending substantially cylindrical mixing chamber having

a pulp inlet opening near one end and

a pulp outlet opening near the other end,

means for feeding pulp from said inlet through said chamber under pressure to said outlet,

a rotatable impeller shaft in said chamber extending 15
axially thereof,

a liquid inlet pipe extending transversely of said chamber near the axis thereof and having a series of liquid inlet openings therein for injecting liquid into pulp in a downstream direction across a transverse 20
line approaching a diameter of said cylindrical chamber,

a set of concavely curved pulp rotating vanes radially extending from said impeller shaft and rotatable therewith adjacent said liquid inlet for spreading 25
injected liquid in the pulp for entrainment in transverse layers while impelling pulp rotatably and toward the outlet opening end of the chamber,

a set of oppositely curved pulp rotation impeding vanes fixedly extending radially inwardly from the walls of said chamber toward and close to said shaft for checking rotation of the pulp in the chamber as it is fed toward the outlet and thereby breaking up the layers of pulp and entrained liquid,

a first helical kneading blade in said chamber downstream of said sets of vanes extending along said shaft and rotatable therewith to work the pulp radially and longitudinally of said chamber toward one end thereof,

a second helical kneading blade adjacent said first and of opposite hand extending along said shaft and rotatable therewith to work the pulp reversely radially and longitudinally of said chamber toward the opposite end thereof and

means for discharging pulp from said pulp outlet opening beyond said helical kneading blades.

3. Apparatus for mixing a liquid with a pulp mass comprising,

a longitudinally extending mixing chamber having 50
a pulp inlet opening near one end and

a pulp outlet opening near the other end,

means for feeding pulp longitudinally under pressure from said inlet downstream through said chamber to said outlet,

a liquid inlet pipe extending transversely of said chamber near the axis thereof and having a series of liquid inlet openings therein for injecting liquid into pulp in a downstream direction across a transverse 60
line approaching a diameter of said cylindrical chamber,

rotary means adjacent said liquid inlet rotating the pulp across a plane transverse of said chamber for spreading injected liquid in transverse layers within the pulp while pulp is fed longitudinally in said chamber,

at least one rotary helical kneading blade in said chamber downstream of said rotary means extending longitudinally of said chamber and rotatable therein to work the pulp and entrained liquid longitudinally reversely, toward said pulp inlet end and

means beyond said kneading blade for discharging mixed liquid and pulp from said pulp outlet opening.

4. Apparatus for mixing a liquid with a pulp mass comprising,

a longitudinally extending mixing chamber having a pulp inlet opening near one end and

a pulp opening near the other end,

means for feeding pulp longitudinally under pressure from said inlet downstream through said chamber to said outlet,

a liquid inlet pipe extending transversely of said chamber near the axis thereof and having a series of liquid inlet openings therein for injecting liquid into pulp in a downstream direction across a transverse line approaching a diameter of said cylindrical chamber,

radially extending pulp rotating vanes rotatable in said chamber in a transverse plane downstream adjacent the transverse liquid inlet for spreading injected liquid transversely within the pulp for entrainment in layers while rotating the pulp mass in said chamber,

a first helical kneading blade downstream of said vanes extending longitudinally of said chamber and rotatable therein to work the pulp and entrained liquid both radially of the chamber and longitudinally thereof toward said outlet end,

a second helical kneading blade of opposite hand extending longitudinally of said chamber and rotatable therein to work the pulp reversely both radially and longitudinally of said chamber toward said pulp inlet end and

means beyond said helical kneading blades for discharging pulp from said pulp outlet opening.

5. Apparatus according to claim 4 in which said first and second helical kneading blades are concentrically mounted one with respect to the other in the same longitudinal space within said chamber.

6. Apparatus according to claim 4 in which said helical kneading blades each are tapered spirally from a small diameter at one end to a larger diameter at the other end to induce kneading action radially of said chamber.

7. Apparatus according to claim 4 in which said second helical kneading blade is mounted downstream of said first helical kneading blade in said mixing chamber.

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