

June 4, 1963

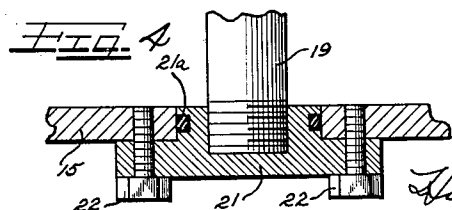
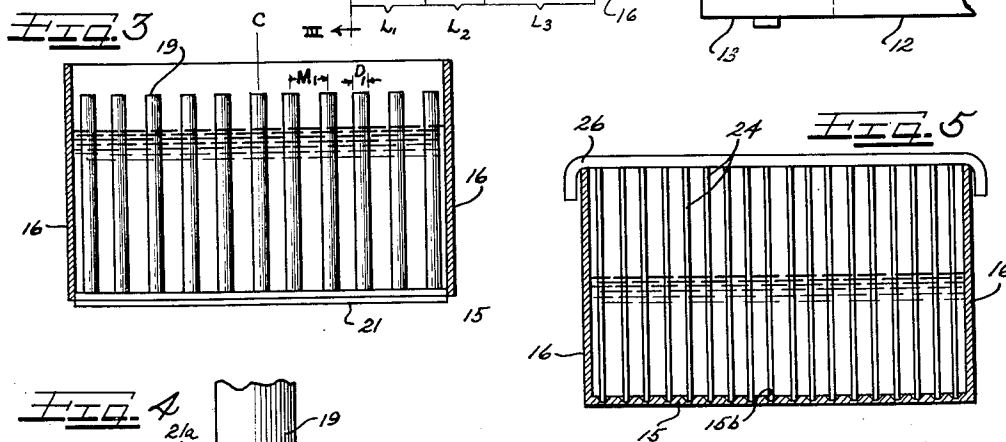
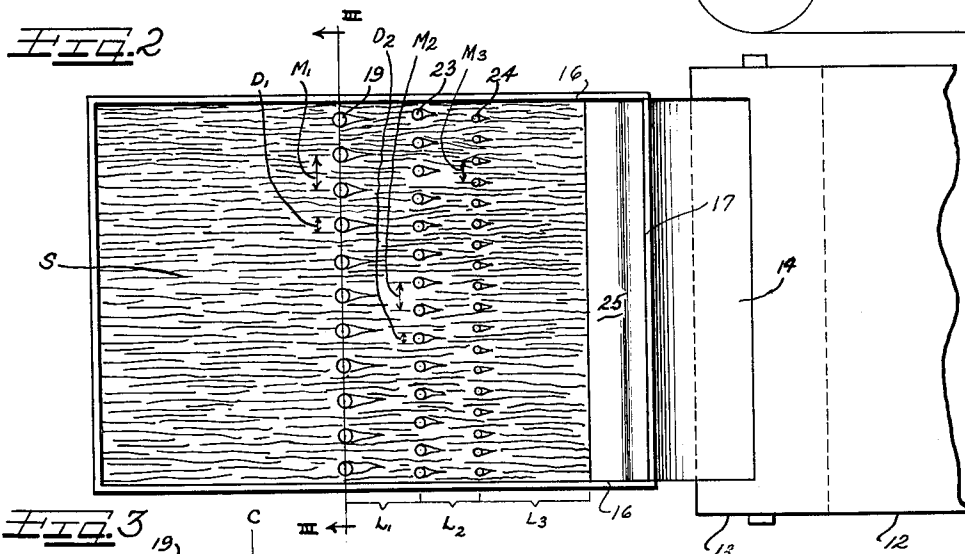
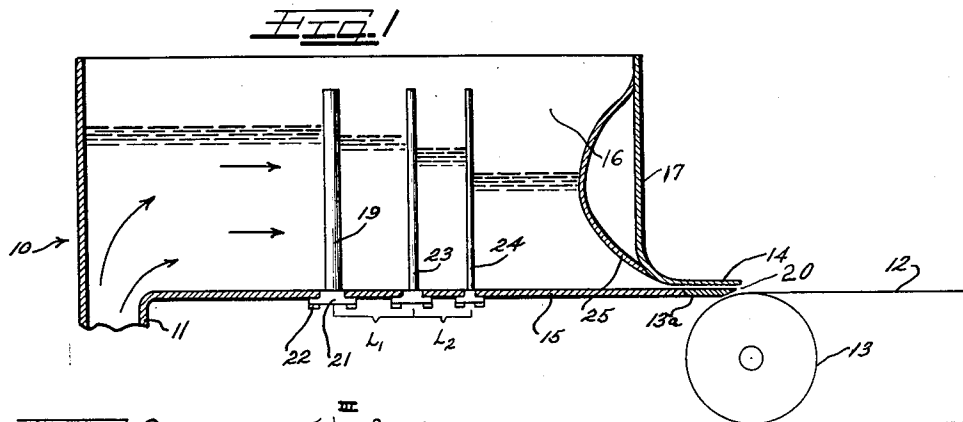
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3,092,540

METHOD AND APPARATUS FOR DISTRIBUTING PARTICLE SUSPENSIONS

Filed Nov. 9, 1960

2 Sheets-Sheet 1



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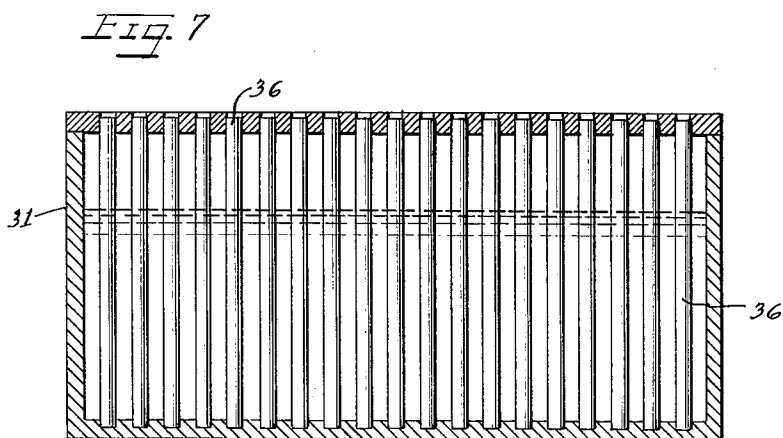
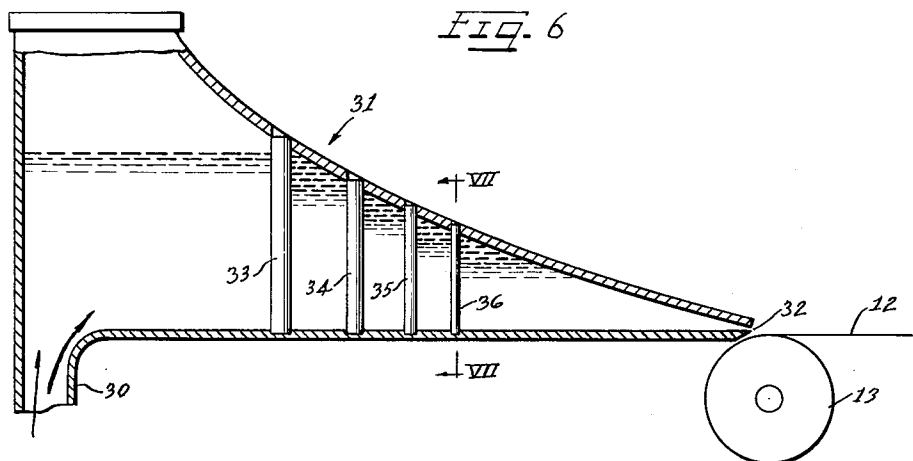
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METHOD AND APPARATUS FOR DISTRIBUTING PARTICLE SUSPENSIONS

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2 Sheets-Sheet 2



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3,092,540

METHOD AND APPARATUS FOR DISTRIBUTING PARTICLE SUSPENSIONS

Joseph D. Parker, Beloit, Wis., assignor to Beloit Iron Works, Beloit, Wis., a corporation of Wisconsin
Filed Nov. 9, 1960, Ser. No. 68,303
10 Claims. (Cl. 162—343)

This invention relates to the handling of fluid slurries and is more particularly directed to the maintenance of fiber dispersion in stock slurries for papermaking and like processes.

Prior attempts to establish uniform distribution of the fibers in the stock slurry and to maintain fiber distribution, once established, along the flow path in the head box prior to deposition of the slurry on the forming surface have involved employment of such complicated auxiliary equipments as perforated rotary rolls, commonly referred to as rectifier rolls, holey rolls, or silencing rolls, and other mechanical vibrating, shaking and stirring devices, all of which induced turbulent flow currents of large amplitude in the slurry.

A major disadvantage attendant use of such prior art devices resides in the tendency of the fibers to form clots, floc, or agglomerations which, when deposited on the forming surface, result in undesirable localized irregularities of high density in the forming mat. In some instances, such clots and the like break down the mat, thereby interrupting production.

By employment of the present invention, I eliminate the requirement for rotary, vibrating or other moving auxiliary means in the headbox and provide for delivery of the stock slurry to the forming surface of a papermaking machine under conditions of substantially uniform mean velocity, minimum large scale flow turbulence, and minimum gross secondary flow patterns wherein the fiber distribution and dispersion in the liquid vehicle are substantially uniform, thereby permitting formation on the forming surface of a mat having substantially uniform density and fiber distribution throughout. The practice of the present invention also substantially reduces the formation of undesirable clots, floc or agglomerations in the turbulent slurry.

It is another feature of this invention to provide apparatus for producing successively smaller scale turbulence in a paper stock slurry thereby increasing uniform distribution of fibers in the slurry without substantially increasing formation of clots or agglomeration therein.

It is therefore an object of the present invention to provide improved methods and means for establishing and maintaining particles of substantially uniform mean distribution in a liquid medium.

It is another object of this invention to provide improved methods and means for delivering a stock slurry to the forming surface of a papermaking machine under conditions of substantially uniform mean velocity, minimum large scale flow turbulence and minimum gross secondary flow patterns wherein fiber distribution in the liquid vehicle is substantially uniform to thereby permit formation of a mat of substantially uniform density and fiber distribution on the forming surface.

It is still another object of the present invention to eliminate the requirements for rotary, vibratory, or other moving auxiliary means in the inlet of papermaking machines by providing for delivery of the stock slurry to the forming surface of the papermaking machine under conditions of substantially uniform mean velocity, minimum large scale flow turbulence and minimum gross secondary flow patterns wherein fiber distribution in the liquid vehicle is improved.

It is a further object of the present invention to sub-

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stantially reduce formation of undesirable clots, floc, or agglomerations in stock slurry in the headbox of a papermaking machine.

It is yet another object of the present invention to control the conditions of flow of a stock slurry immediately prior to delivery thereof to the forming surface of a papermaking machine.

It is another object of the present invention to provide apparatus for flowing a stream of slurry from an inlet to an outlet through a channel directing flow of the slurry wherein a first bank of turbulent generator abutments are positioned in the flow path for producing eddy currents of a first order amplitude in the slurry and wherein a second bank of turbulent generator abutments are located in the flow path of a predetermined distance downstream from the first bank at a location where the first order eddy currents are in a condition of partial decay for further producing second order eddy currents greater in number but of lesser amplitude than the first order eddy currents, said second bank of turbulent generators being located also a predetermined distance from the outlet to permit partial decay of the second order eddy currents whereby the slurry is delivered to the outlet in a condition of uniform mean velocity with a minimum amount of large scale turbulence and a minimum amount of gross secondary flow patterns and with a well dispersed fiber content.

A further object of the present invention is to provide apparatus for controlling the distribution of fibers in a slurry which is simple and compact in construction and efficient and high speed in operation.

These and other objects, features and advantages of the present invention will become more apparent upon a careful consideration of the following detailed description when considered in conjunction with the accompanying drawings illustrating preferred embodiments of the present invention and wherein like reference characters and numerals refer to like or corresponding parts through the several views.

On the drawings:

FIGURE 1 is a view in side elevation of apparatus found useful in the practice of the present invention.

FIGURE 2 is a top view of the apparatus of FIGURE 1.

FIGURE 3 is a view taken along lines III—III of FIGURE 2.

FIGURE 4 is an enlarged fragmentary view of the abutment support member of FIGURE 1.

FIGURE 5 is a view in cross section of an alternative embodiment of the present invention.

FIGURE 6 is a view in cross section of another embodiment of the present invention.

FIGURE 7 is a view taken along lines VII—VII of FIGURE 6.

As shown on the drawings:

Briefly stated, the present invention involves the discovery of the dimensional correlation between the location, size, and spacing of turbulent generators comprising banks of abutments sequentially positioned in the flow path of a fluid vehicle carrying a plurality of discrete particles whereby the banks of abutments create successively finer scale turbulence of high order intensity in the liquid vehicle and thereby an increasing high order of particle dispersion or distribution throughout the liquid vehicle.

The turbulence created must be of high order and fine scale, particularly for papermaking applications wherein the paper stock slurry is to be conditioned prior to deposition thereof on the forming surface of a papermaking machine. Large scale turbulence will give rise to undesirable effects in the stock slurry flowing to the paper machine, e.g., floccing.

Experience has indicated that employment of abut-

ments in the slurry flow path in a conventional headbox of a papermaking machine may provide such high order and fine scale turbulence in the stock and that, by positioning abutments in a location of partial turbulence decay, the flocculation of the flowing stock is reduced.

In FIG. 1, reference numeral 10 indicates generally an inlet or headbox for a Fourdrinier type papermaking machine, the box 10 receiving the stock from an upwardly and inwardly directed conduit 11 for subsequent introduction of the stock onto the forming wire 12 looped about a breast roll 13 in a conventional Fourdrinier type papermaking machine. The stock flows through the box 10 and then through the slice at 14 and onto the forming wire 12 where the web W is formed.

The inlet box 10 may be a closed box provided with an air pressure supply means (not shown) for accelerating the flow of stock through the slice 14 or the inlet box 10 may be, as shown, an open topped inlet box which is defined generally by a bottom wall 15 terminating in a forward arcuate apron portion 15a, a pair of side walls 16, 16, a rear wall and a forward wall 17. The forward arcuate apron portion 15a is shown tapered at its forward end terminating substantially at the top center of the breast roll 13 so that the stock flowing thereover from the stock inlet box 10 may flow onto the upper run of the forming wire 12 while the wire is supported by the breast roll 13 and the usual Fourdrinier structure in a substantially horizontal plane as it passes over the top center of the roll behind the top peripheral portion thereof.

The floor or bottom wall 15, sidewalls 16, rear wall and the forward wall 17 cooperate to define the stock pond or chamber wherein stock S is flowed from the inlet to the outlet under a pressure gradient.

The force driving the stock through the outlet 20 is primarily a hydraulic force exerted by the stock at the outlet 20. The hydraulic force is determined by the hydraulic head of the stock in the inlet 11 and by pressure on top of the stock.

The apparatus thus far described is conventional in nature and forms no part of the present invention.

In accordance with the present invention, there is positioned in the channel 10 a first bank or array of stationary and preferably vertical abutments 19 extending transverse of the direction of flow of the slurry S, the full width of the flow channel 10. The abutments or turbulence generators 19 are preferably cylindrical rods (which thus present a rounded upstream side to minimize fiber collection thereon and an abruptly terminating, rounded downstream side to create downstream wakes of non-streamline flow), preferably equally spaced in the bank, each parallel to the other, and symmetrically located about the center line C (FIG. 3) of the channel 10. The abutments 19 are preferably of a height greater than the height of the slurry flowing in the channel and are sized relative to the total transverse flow area or width of the channel to occupy preferably about 50% of the width thereby leaving between the abutments a total open flow area of about 50% of the width of the channel 10.

If desired, the bottom or floor of the channel 15 may be provided with threaded apertures and the ends of the rods 19 complementarily threaded for assembly in the channel, or, as shown in the drawing, the bottom of the channel 15 may be transversely slotted to receive the flanged base member 21, and the abutments 19 may be threaded into the base member 21, the base member fitted into the slot in the channel floor and secured thereto as by screws 22 passing through the channel bottom 15 as appears in FIG. 4. A seal 21a may be provided.

Thus, the turbulence generators 19 may be pre-assembled in the support 21 and the complete turbulence generator unit secured in the headbox or flow channel 10.

The turbulence generators or abutments 19 are provided for increasing the intensity and reducing the scale of turbulence in the slurry. In other words, the flow pattern of the slurry downstream of the abutments 19 is changed

to a condition exhibiting a uniform pattern of first order eddy currents of a first magnitude.

The abutments 19 may be spaced across the width of the flow channel so as to provide a total flow area therebetween within the range of from about 10% to about 90% of the width of the channel, while I prefer to employ a sufficient number of abutments 19 to define a total flow area between abutments within the range of from about 20% to about 80%, and, as aforesaid, excellent fiber distribution is obtained where the total flow area between the abutments in the bank is approximately 50% of the width of the channel.

The ratio of the cross-sectional dimension D_1 (FIG. 2) of each abutment 19 and the distance M_1 , the distance from the center of one abutment to the center of an adjacent abutment, is equal to one-half. Experience has indicated that with extremely small D/M ratios, i.e., less than one-half, the turbulence produced downstream of the abutments is not as great as is desired for distributing and dispersing the stock. On the other hand, with extremely large D/M ratios, i.e., greater than $\frac{1}{2}$, undesirable jetting velocities through the open area between abutments occurs, because of the pressure drop experienced by the flowing stream.

Any conventional means may be employed to present the slurry under a pressure gradient to the first bank of abutments which will generate sufficient turbulence in the slurry upstream of the abutments to prevent floccing of the fibers in the slurry at and adjacent the abutments.

The turbulence created in the slurry downstream of the first bank of abutments therefore must be sufficient to sweep the surface of each of the abutments to thereby prevent formation of "stagnation areas" where fiber particles tend to settle out of the flow stream in agglomerations or clots. It will be appreciated therefore that the abutments of the first bank must be of sufficient size to avoid the phenomenon known as "stapling." Thus, the turbulence in the flow approaching and passing the abutments in the first bank must be sufficient to prevent floccing or clotting in this area.

Located a distance L_1 downstream from the bank of abutments 19 is a second bank of abutments 23. The distance L_1 is approximately equal to about two to about five times the distance M_1 of the upstream bank of abutments 19. This distance is advantageously chosen for employment of the behavior of the turbulent wakes generated behind each of the abutments 19. Maximum intensity of the flow turbulence appears to occur from about 2 to about 4 distances M_1 from the upstream bank of abutments 19 at high stock flow velocities, it being understood, of course, that the turbulence intensity is dependent on velocity, and thus, the distance between the banks of abutments in turn is dependent on these factors. At distances from the first bank of abutments greater than those set forth, the turbulence flow generated in the slurry by the abutments 19 tends to dissipate or decay and to merge into a uniform mean flow pattern.

Thus, the second bank of abutments is located a distance downstream from the first bank, said distance being greater than the distance to the zone of maximum intensity of the first order flow turbulence created in the slurry by the first bank of abutments but less than the distance from the first bank of abutments where a uniform mean flow occurs.

I have found that, if the abutments 23 of the second bank are of smaller size, and, therefore, in greater number, than the abutments 19 and are located from about two to about five times the distance M_1 of the first bank of abutments, thereby placing the second bank in an area wherein the initially induced first order eddy currents are partially decaying, a second order of eddy currents greater in number but lesser in magnitude than the first order eddy currents are generated in the slurry passing through the open area between the second bank of abut-

ments. This second order of eddy currents tends to further disperse and distribute the fibers throughout the slurry while the amplitude of the second order eddy currents is reduced relative to the amplitude of the first order eddy currents.

It will be appreciated that in order to induce a greater number of eddy currents than the first order of eddy currents, the dimensions D_2 and the center-to-center distance M_2 of adjacent abutments 23 in the second bank of abutments is less than the dimension D_1 and distance M_1 of the first bank of abutments. Excellent fiber distribution results are obtained where the total open flow area between the abutments 23 in the second bank is approximately 50% of the width of the channel.

The slurry, in this fine scale turbulent condition, may be then flowed past a third bank of abutments 24 located a distance L_2 from the second bank of abutments, the distance L_2 being determined in the same manner as the distance L_1 . However, if the bank of abutments 24 constitutes the last bank of abutments adjacent the slice gate 25 and forming wire, the distance relationship between the last bank 24 and the slice gate must be taken into consideration in determining the proper location of the bank of abutments 24 and will lie in the range of from about three to about seven times M_3 , M_3 being the distance from the center of one abutment 26 to the center of an adjacent abutment in the third bank.

To increase dispersion or distribution of the fibers in the slurry by generating a still finer scale turbulence in the slurry, each of the abutments 24 in the final bank or third bank of abutments are preferably of the minimum size permissible in terms of structural strength and the like. In addition, the location L_3 of the last bank of abutments should be at a distance from the outlet 20 sufficient to permit a partial decay of the turbulence generated by the abutments 24 whereby the slurry is delivered to the outlet 20 with the fiber content thereof in a uniformly well dispersed state.

The dimension D , distance M , and D/M ratio are determined for each bank of abutments in accordance with the procedure outlined above in connection with the determination of the dimension D_1 , distance M_1 and dimension-to-distance ratio of the first bank of abutments.

The abutments 19, 23 and 24 may be of any cross-sectional shape desired, for example, round, square, triangular, and the like, but I prefer to employ cylindrical rods. It is also contemplated within the scope of the present invention to substitute perforated or slotted plates or grids for the banks of rods. In addition, the rods may be employed to maintain the desired structural dimension of the inlet channel, as, for example, between the channel walls 16, 16.

It will be appreciated that additional intermediate banks of abutments may be employed in the practice of the present invention and that the dimension, D , distance M , and dimension-to-distance ratio D/M , and distances between adjacent banks will be determined in accordance with the procedures outlined above in determining the corresponding dimensions.

By positioning intermediate banks, such as the abutments 23 in the wakes of the first bank of abutments 19, means are thereby provided to avoid formation of stagnation points adjacent the downstream bank of abutments 23 where fiber particles might tend to settle out of the flow stream and create agglomerations or clots. Each of the successive intermediate banks, if employed, and the final bank of abutments adjacent the channel outlet, are positioned so that the distance therebetween is sufficient to permit sweeping of each of the intermediate and final banks by the turbulence created in the slurry by the adjacent upstream bank of abutments. Thus, the entire system of turbulence generators or banks of abutments may be made self-cleaning and tends to prevent the deposition on the forming surface of agglomerations of fibers.

For employment with open topped headboxes or flow

channels, the alternate embodiment of the present invention appearing in FIGURE 5 may be employed wherein each of the abutments 24 may be mounted at one end and at equally spaced intervals in a flanged member 26 which extends across the top of the headbox and is supported by the side walls 16, 16. The opposite ends of the abutments may be seated in recesses 15b formed in the floor of the headbox 15.

It will be appreciated that, while the present invention is disclosed in connection with a flow channel or headbox for a conventional Fourdrinier machine, the apparatus and method of the present invention has application with the cylindrical type papermaking machines. It will also be understood that, while the turbulence generators are disclosed in connection with an open channel type headbox of conventional design, the present invention has application with the enclosed channel design such as that found in U.S. Patent No. 2,658,431, issued November 10, 1953, and similar enclosed channel devices, an example of which appears in FIGURE 6.

In the embodiment shown in FIGURE 6, stock is directed upward through the channel inlet 30 under a pressure gradient and flows through a convergingly tapered channel, generally indicated by the numeral 31 to the outlet thereof 32 positioned adjacent the forming wire 12 and breast roll 13 of a conventional Fourdrinier machine. Positioned within the channel 31 are a plurality of banks of abutments 33, 34, 35 and 36 which are dimensioned and spaced as indicated above in connection with the description of the banks of abutments of FIGURE 1. The abutment system of FIGURE 6 increases the fine scale turbulence in the slurry and improves fiber distribution prior to deposition of the slurry on the forming wire 12.

In the open channel headbox such as that disclosed in FIGURE 1, the abutments are preferably vertically positioned, whereas in the enclosed channel type apparatus, the orientation of the rods does not appear to significantly affect operation of the system.

The turbulence generation system of the present invention may include any conventional means for distributing and dispersing the slurry upstream of the first bank of abutments, as, for example, a cross flow spreader similar to that shown in the Beachler U.S. Patent No. 2,911,041.

Although various minor modifications might be suggested by those skilled in the art, it should be understood that I wish to embody within the scope of the patent warranted hereon, all such embodiments as reasonably and properly come within the scope of my contribution to the art.

I claim as my invention:

1. Apparatus for delivering a stock slurry to the forming surface of a papermaking machine in a condition exhibiting substantially uniform fiber distribution in the slurry comprising: a first transversely extending bank of a multiplicity of spaced abutments located in the flow path of the slurry for generating a uniform pattern of small scale turbulence of a first order magnitude in the slurry, the abutments in the first bank being relatively small sized and substantial in number to occupy from about 10% to about 90% of the cross-sectional area of the slurry flow path, at least a second transversely extending bank of abutments located a distance approximately equal to from 2 to about 5 times the distance between the center-to-center points of a pair of adjacent abutments in the first bank whereby the second bank of abutments are located in the turbulent wake of the first bank of abutments, the abutments of said second bank being substantially greater in number than and substantially smaller in size than those of the first bank for generating a uniform pattern of smaller scale turbulences in the slurry, and means for guiding the flow of slurry to the forming surface of the papermaking machine to permit partial decay of the turbulence before delivery of the slurry to the forming surface.

2. Apparatus for delivering a stock slurry to the forming surface of a papermaking machine in a condition exhibiting substantially uniform fiber distribution in the slurry comprising: a first transversely extending bank of spaced abutments located in the flow path of the slurry for generating a uniform pattern of small scale turbulence of a first order magnitude in the slurry, the abutments in the first bank being sized to occupy from about 20% to about 80% of the cross-sectional area of the slurry flow path, at least a second transversely extending bank of spaced abutments located a distance approximately equal to from about two to five times the distance between the center-to-center points of a pair of adjacent abutments in the first bank whereby the second bank of abutments are located in the turbulent wake of the first bank of abutments for generating a uniform pattern of smaller scale turbulence in the slurry, and means for guiding the flow of slurry to the forming surface of the papermaking machine to permit partial decay of the turbulence before delivery thereof to the forming surface, said first bank containing a multiplicity of abutments and the second bank containing abutments that are substantially greater in number and smaller in size than the abutments of the first bank.

3. Apparatus for delivering a stock slurry to the forming surface of a papermaking machine in a condition exhibiting substantially uniform fiber distribution in the slurry comprising: a first transversely extending bank of a multiplicity of equally spaced and parallel abutments located in the flow path of the slurry for generating a uniform pattern of small scale turbulence of a first order magnitude in the slurry, the abutments in the first bank being sized to occupy approximately 50% of the cross-sectional area of the slurry flow path, at least a second transversely extending bank of a multiplicity of equally spaced and parallel abutments located a distance approximately equal to from about two to five times the distance between the center-to-center points of a pair of adjacent abutments in the first bank whereby the second bank of abutments are located in the turbulent wake of the first bank of abutments for generating a uniform pattern of smaller scale turbulence in the slurry, the abutments in the second bank of abutments being sized to occupy approximately 50% of the cross-sectional area of the slurry flow path, and means for guiding the flow of slurry to the forming surface of the papermaking machine to permit partial decay of the turbulence in the slurry before delivery thereof to the forming surface, said abutments in each bank being in the form of rods each having a transverse dimension that is substantially one-half of the distance between the center-to-center points of such rod and the immediately adjacent rod, and the rods in the second bank being substantially smaller and greater in number than those in the first bank.

4. Apparatus for delivering a stock slurry to the forming surface of a paper making machine in a condition exhibiting substantially uniform fiber distribution, which comprises a first bank of abutments extending transversely in the flow path of the slurry for generating a uniform pattern of small scale turbulence in the slurry to thereby distribute the fibers in the slurry, a plurality of additional transverse banks of abutments downstream of the first bank of abutments, the abutments in each such additional bank being located downstream from their immediately upstream bank approximately 2 to 5 times the distance between the center-to-center points of a pair of adjacent abutments in such immediately upstream bank, the abutments in each such additional bank of abutments being of substantially less size and in substantially greater number than the abutments in their immediately upstream bank for generating at each such additional bank of abutments uniform patterns of successively smaller scale turbulence in the slurry, each such additional bank of abutments being located in an area of the flow path where the uniform pattern of turbulence from the im-

mediately upstream bank is in a condition of partial decay, and means for guiding the slurry to the forming surface of a paper making machine whereby the slurry is delivered to the forming surface while the slurry turbulence is in a condition of partial decay, the abutments in each of said banks presenting a multiplicity of turbulence generating land areas with a multiplicity of open areas therebetween to accommodate stock flow and the abutments terminating abruptly on their downstream sides, whereby collection of stock fibers at the oncoming side is minimized and wakes of non-streamline flow are created at the downstream sides of such abutments.

5. Apparatus for delivering a stock slurry to the forming surface of a paper making machine in a condition exhibiting substantially uniform fiber distribution, which comprises a first bank of abutments extending transversely in the flow path of the slurry for generating a uniform pattern of small scale turbulence in the slurry to thereby distribute the fibers in the slurry, a plurality of additional transverse banks of abutments downstream of the first bank of abutments, the abutments in each such additional bank being located downstream from their immediately upstream bank approximately 2 to 5 times the distance between the center-to-center points of a pair of adjacent abutments in such immediately upstream bank, the abutments in each such additional bank of abutments being of substantially less size and in substantially greater number than the abutments in their immediately upstream bank for generating at each such additional bank of abutments uniform patterns of successively smaller scale turbulence in the slurry, each such additional bank of abutments being located in an area of the flow path where the uniform pattern of turbulence from the immediately upstream bank is in a condition of partial decay, and means for guiding the slurry to the forming surface of a paper making machine whereby the slurry is delivered to the forming surface while the slurry turbulence is in a condition of partial decay, the abutments in each of said banks presenting a multiplicity of turbulence generating land areas with a multiplicity of open areas therebetween to accommodate stock flow, with each such land area in a given bank having a transverse dimension that is substantially one-half the distance between center-to-center points of a pair of adjacent abutments in such given bank, and the abutments terminating abruptly on their downstream sides, whereby collection of stock fibers at the oncoming side is minimized and wakes of non-streamline flow are created at the downstream sides of such abutments.

6. Apparatus for delivering a stock slurry to the forming surface of a paper making machine in a condition exhibiting substantially uniform fiber distribution, which comprises a first bank of abutments extending transversely in the flow path of the slurry for generating a uniform pattern of small scale turbulence in the slurry to thereby distribute the fibers in the slurry, a plurality of additional transverse banks of abutments downstream of the first bank of abutments, the abutments in each such additional bank being located downstream from their immediately upstream bank approximately 2 to 5 times the distance between the center-to-center points of a pair of adjacent abutments in such immediately upstream bank, the abutments in each such additional bank of abutments being of substantially less size and in substantially greater number than the abutments in their immediately upstream bank for generating at each such additional bank of abutments uniform patterns of successively smaller scale turbulence in the slurry, each such additional bank of abutments being located in an area of the flow path where the uniform pattern of turbulence from the immediately upstream bank is in a condition of partial decay, and means defining a slice for guiding the slurry to a paper machine forming surface, such slice being located downstream from the downstream-most bank of abutments approximately 3 to 7 times the distance be-

tween the center-to-center points of a pair of adjacent abutments in such downstream-most bank, whereby the slurry is delivered to the forming surface while the slurry turbulence is in a condition of partial decay, the abutments in each of said banks presenting a multiplicity of turbulence generating land areas with a multiplicity of open areas therebetween to accommodate stock flow and the abutments terminating abruptly on their downstream sides, whereby collection of stock fibers at the oncoming side is minimized and wakes of non-streamline flow are created at the downstream sides of such abutments.

7. Apparatus for delivering a stock slurry to the forming surface of a paper making machine in a condition exhibiting substantially uniform fiber distribution, which comprises a first bank of abutments extending transversely in the flow path of the slurry for generating a uniform pattern of small scale turbulence in the slurry to thereby distribute the fibers in the slurry, a plurality of additional transverse banks of abutments downstream of the first bank of abutments, the abutments in each such additional bank being located downstream from their immediately upstream bank approximately 2 to 5 times the distance between the center-to-center points of a pair of adjacent abutments in such immediately upstream bank, the abutments in each such additional bank of abutments being of substantially less size and in substantially greater number than the abutments in their immediately upstream bank for generating at each such additional bank of abutments uniform patterns of successively smaller scale turbulence in the slurry, each such additional bank of abutments being located in an area of the flow path where the uniform pattern of turbulence from the immediately upstream bank is in a condition of partial decay, and means defining a slice for guiding the slurry to a paper machine forming surface, such slice being located downstream from the downstream-most bank of abutments approximately 3 to 7 times the distance between the center-to-center points of a pair of adjacent abutments in such downstream-most bank whereby the slurry is delivered to the forming surface while the slurry turbulence is in a condition of partial decay, the abutments in each of said banks consisting essentially of rods of generally cylindrical cross section presenting a multiplicity of turbulence generating land areas with a multiplicity of open areas therebetween to accommodate stock flow, whereby collection of stock fibers at the oncoming side is minimized and wakes of non-streamline flow are created at the downstream sides of such abutments.

8. Apparatus for delivering a stock slurry to the forming surface of a paper making machine in a condition exhibiting substantially uniform fiber distribution, which comprises a first bank of abutments extending transversely in the flow path of the slurry for generating a uniform pattern of small scale turbulence in the slurry to thereby distribute the fibers in the slurry, a plurality of additional transverse banks of abutments downstream of the first bank of abutments, the abutments in each such additional bank being located downstream from their immediately upstream bank approximately 2 to 5 times the distance between the center-to-center points of a pair of adjacent abutments in such immediately upstream bank, the abutments in each such additional bank of abutments being of substantially less size and in substantially greater number than the abutments in their immediately upstream bank for generating at each such additional bank of abutments uniform patterns of successively smaller scale turbulence in the slurry, each such additional bank of abutments being located in an area of the flow path where the uniform pattern of turbulence from the immediately upstream bank is in a condition of partial decay, and means defining a slice for guiding the slurry to a paper machine forming surface, such slice being located downstream from the downstream-most bank of abutments approximately 3 to 7 times the distance between the center-to-center points of a pair of adjacent abutments in

such downstream-most bank, whereby the slurry is delivered to the forming surface while the slurry turbulence is in a condition of partial decay, the abutments in each of said banks consisting essentially of cylindrical, equally spaced, generally vertical and parallel rods occupying substantially 50% of the total transverse area with a multiplicity of open areas therebetween to accommodate stock flow, whereby collection of stock fibers at the oncoming side is minimized and wakes of non-streamline flow are created at the downstream sides of such abutments.

9. Apparatus for delivering a stock slurry to the forming surface of a paper making machine in a condition exhibiting substantially uniform fiber distribution, which comprises a first bank of abutments extending transversely in the flow path of the slurry for generating a uniform pattern of small scale turbulence in the slurry to thereby distribute the fibers in the slurry, a plurality of additional transverse banks of abutments downstream of the first bank of abutments, the abutments in each such additional bank being located downstream from their immediately upstream bank approximately 2 to 5 times the distance between the center-to-center points of a pair of adjacent abutments in such immediately upstream bank, the abutments in each such additional bank of abutments being of substantially less size and in substantially greater number than the abutments in their immediately upstream bank for generating at each such additional bank of abutments uniform patterns of successively smaller scale turbulence in the slurry, each such additional bank of abutments being located in an area of the flow path where the uniform pattern of turbulence from the immediately upstream bank is in a condition of partial decay, and means for guiding the slurry to the forming surface of a paper making machine whereby the slurry is delivered to the forming surface while the slurry turbulence is in a condition of partial decay, the abutments in each of said banks consisting essentially of cylindrical, equally spaced, generally vertical and parallel rods occupying substantially 50% of the total transverse area with a multiplicity of open areas therebetween to accommodate stock flow, whereby collection of stock fibers at the oncoming side is minimized and wakes of non-streamline flow are created at the downstream sides of such abutments.

10. Apparatus for delivering a stock slurry to the forming surface of a paper making machine in a condition exhibiting substantially uniform fiber distribution, which comprises a first bank of abutments extending transversely in the flow path of the slurry for generating a uniform pattern of small scale turbulence in the slurry to thereby distribute the fibers in the slurry, at least one additional transverse bank of abutments downstream of the first bank of abutments, the abutments in said second bank being of substantially less size than the abutments in the first bank of abutments for generating a second uniform pattern of smaller scale turbulence in the slurry, said second bank of abutments being located in an area of the flow path where the first uniform pattern of turbulence is in a condition of partial decay, and means for guiding the slurry to the forming surface of the paper making machine whereby the slurry is delivered to the forming surface while the slurry turbulence is in a condition of partial decay, the abutments in each of said banks presenting a multiplicity of turbulence generating land areas with a multiplicity of open areas therebetween to accommodate stock flow and the abutments terminating abruptly on their downstream sides in the direction of stock flow, whereby collection of stock fibers at the oncoming sides is minimized and wakes of non-streamline flow are created at the downstream sides, the abutments in the second bank being located downstream from the first bank approximately 2 to 5 times the distance between the center-to-center points of a pair of adjacent abutments in the first bank.

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