Oct. 7, 1952 P. L. PENDLETON 2,612,860

FLUID PROCESSING APPARATUS

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Fig. 1.

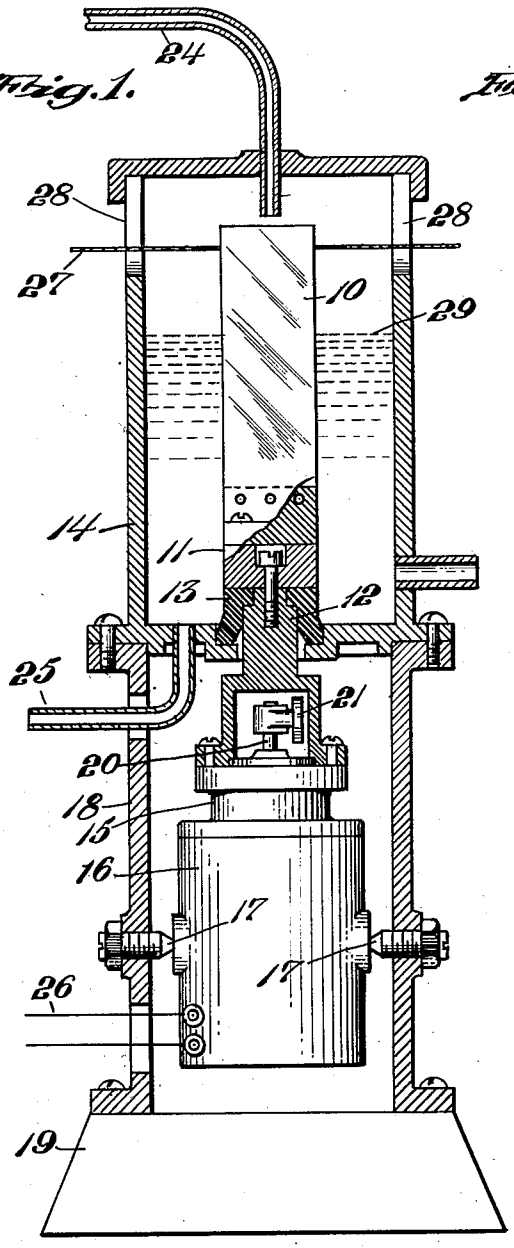
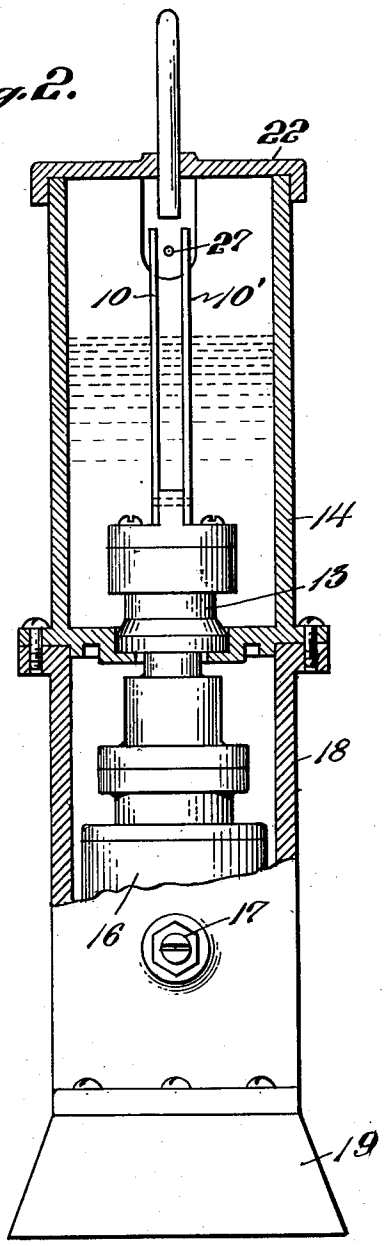


Fig. 2.



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FLUID PROCESSING APPARATUS

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Fig. 3.

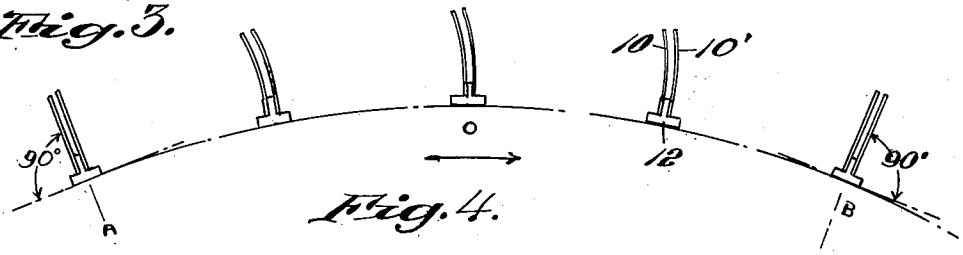


Fig. 4.

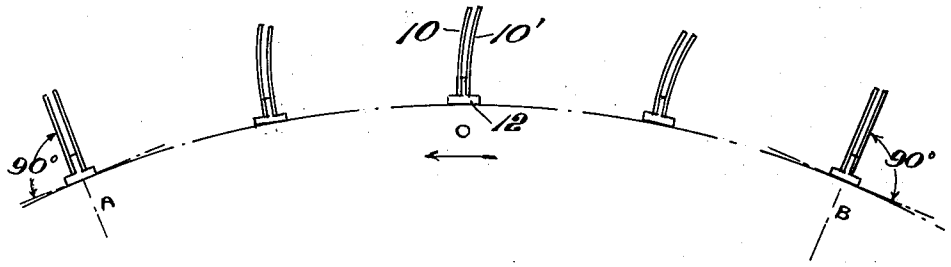
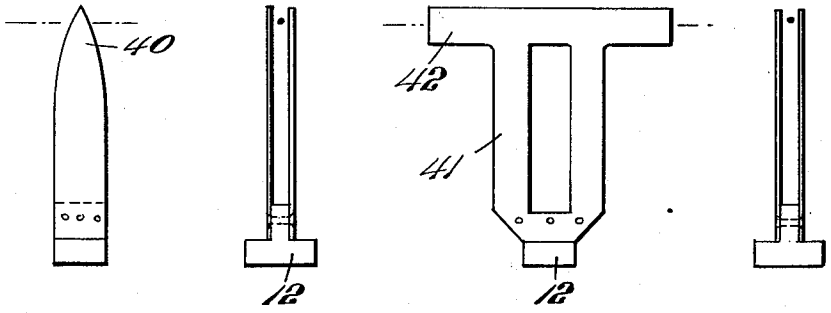


Fig. 5. Fig. 6. Fig. 7. Fig. 8.



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Fig. 9.

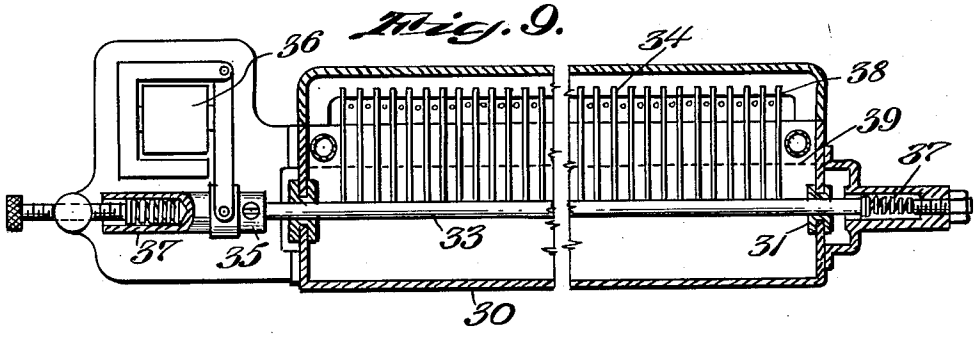


Fig. 10.

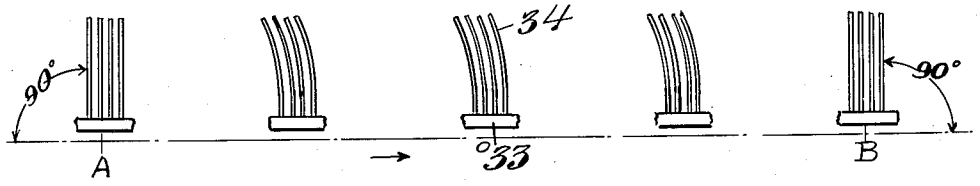


Fig. 11.

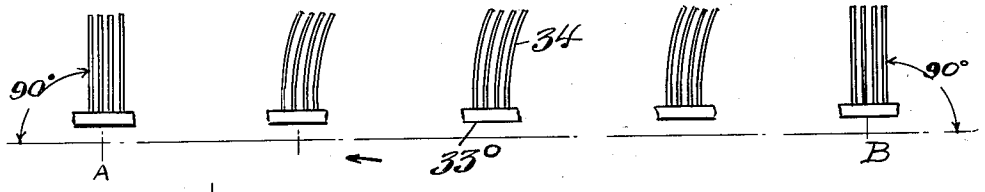
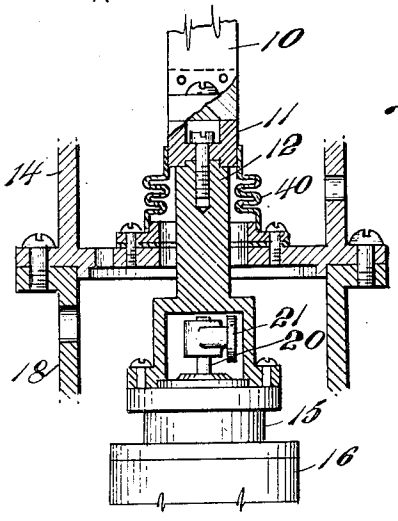


Fig. 12.



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UNITED STATES PATENT OFFICE

2,612,860

FLUID PROCESSING APPARATUS

Pyam L. Pendleton, Cranston, R. I.

Application July 13, 1949, Serial No. 104,573

14 Claims. (Cl. 118—420)

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This invention relates to a new apparatus for manipulating a fluid for a new application of the fluid to continuously running filament, yarn, strand, thread, ribbon, tape, wire or like material. This is a continuation-in-part of my abandoned application, Serial No. 39,758, filed July 20, 1948.

It is well known that fluid pressure circulation may be used to advantage in fluid treatment of strands, the energy of circulation being generally directed toward stimulation of cross sectional flow in and around the strand, between the strand fibres or in and around the ultimate fibre section.

Disadvantages previously encountered, in the use of fluid pressure circulation in strand treatment and more particularly in cases such as the fluid treatment of delicate, stretchy filament yarns traveling at processing speeds of 300 inches per second or more in a continuous running process, are friction between the strand and the fluid or friction between the strand and structural elements of a treating apparatus which may cause disruption of the strand. Other disadvantages have been undesirable turbulence in fluid supply areas external to the actual treating area which may cause evaporation, liberation of gas or thixotropic effects altering the concentration or pH value of a treating solution. It has also been difficult to use solutions having relatively high viscosities in fast running strand fluid treatments.

An object of this invention is to provide an apparatus by which fluid may be superimposed on a moving strand without causing undue turbulence in the supply reservoirs or exerting undue tension or friction on the strand or causing disruption of the fibre.

Another object of this invention is to provide an apparatus which will cause the liquid or fluid which is being used in a treatment to be held between vibrating blades where a strand may pass thru it without causing turbulence to the reservoir of fluid.

Another object of this invention is to provide in the same apparatus a means of more effectively treating strands with fluids of relatively high viscosity.

Another object of the invention is to make possible convenient multiple and simultaneous treatment of multiple strands, which may or may not have been previously subjected to fluid treatment, by the means described.

With these and other objects in view, the invention consists of certain novel features of construction, as will be more fully described, and particularly pointed out in the appended claims.

In the accompanying drawings:

Figs. 1 and 2 are diagrammatic sectional views illustrating right angular positions of a fluid wave generator which is the subject of this invention.

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Figs. 3 and 4 are schematic outlines of the curvilinear blade support reciprocation and associated blade deflection embodied in Figs. 1 and 2.

Figs. 5 and 6 are elevation and edge views of forms of blades where the treating area in the vicinity of the free end is reduced in proportion to the fixed end area which may be partly submerged in fluid in operative practice, the idea being to shorten or lengthen the time of treating effect and thereby lessen the degree of fluid superimposition.

Figs. 7 and 8 are elevation and edge views of forms of blades where the treating area is enlarged to lengthen the time of treating effect and increase the degree of fluid superimposition.

Fig. 9 shows an extended multiple arrangement of blades attached to a common support for simultaneously treating a plurality of strands with the blade support actuation differing from that of Fig. 1 in that it is linear rather than curvilinear reciprocation thereby defining a second type of apparatus otherwise similar in principle.

Figs. 10 and 11 are schematic outlines of the linear blade support reciprocation and associated blade deflection embodied in Fig. 9.

Fig. 12 is a fragmental sectional view similar to Fig. 11 showing a modified form.

It is to be understood that the full range of relation of blade support motion to blade deflection has not been completely shown in either Figs. 3, 4, or 10, 11.

The fluid wave generator as referred to in this application is a device by which energy may be imparted to a static fluid to cause flow in a predetermined direction or to a moving fluid to change the rate or direction of flow, said energy being conveyed as a result of reciprocally moving the fluid at right angles to the desired line of flow by parallel, spaced, resilient members whose common angular relation to the line of reciprocal motion or a tangent to that line at the end of a stroke is a right angle, neglecting lag, but with this angular relation simultaneously changing by variable positive and negative values during reciprocation to create alternating positive and negative pressures against the fluid resulting in a directed flow or wave form, these alternating pressures being positive or negative with respect to static or kinetic heads existing in the fluid.

A feature of this invention is the newly discovered and useful property of fluid wave generators of the species herein described, which may prove to be the discovery of an hitherto unknown or unutilized effect in the field of fluid mechanics, is the substantial containment between adjacent faces of substantially parallel spaced resilient sympathetically vibrating blades which may be produced with regard to a mass of fluid introduced between the blades so that

the contained fluid while being in a state of reciprocating motion and thereby able to transmit kinetic energy may serve in a treating area which may be traversed by a running strand and in which the strand may receive beneficial fluid pressures resulting from substantially unidirectional flow in combination with resultant pressures substantially at right angles to the unidirectional flow. In reductions to practice of this invention sustained and contained flow of the type described has been produced with blades vibrating in the approximate range of 80 to 300 cycles per second.

A particular feature of this invention lies in the use for strand treatment of rapidly reciprocating fluid pressures transmitted alternately along a line substantially perpendicular to the adjacent faces of vibrating blades said line passing thru the section of a strand running between the adjacent faces. As pressures in a direction of flow may exist in combination with pressures substantially at right angles to a direction of flow under these conditions the apparatus will function as a fluid wave generator having alternating pressure characteristics and comparable for the purposes of analysis with other forms of well known fluid wave generators except that the propagating means and wave boundaries are novel.

In the reductions to practice of this invention and the attainment of its objects I have made use of my discovery that if substantially parallel spaced blades of a resilient material are attached to a blade support in a form similar to a comb so that adjacent free ends of the blades may independently vibrate at the same frequency and if the blade support is given linear or slightly curvilinear periodic reciprocation at a frequency agreeing with the natural frequency of vibration of the blades said reciprocation being along a line substantially parallel to a line passing thru the centres of inertia of the blades or along a curve where a tangent at the mean point of reciprocation has the same reference, the fluid introduced between the adjacent blade surfaces at a point away from their free ends will be impelled by the blades toward their free ends and that this flow will be substantially confined and directed along the blades in the area bounded on two sides by the blades and open on the other two sides.

I have found that this flow in the area between the blades has the characteristics of a fluid wave motion and that a fluid wave generated under the conditions described flows away from the point of attachment of the blade to the blade support and toward the tip or free end of the blade to exert fluid pressure against the strand positioned between the blades as a result of the fluid flow while at the same time the strand may receive useful instantaneous fluid pressures at right angles to the flow in the blades as a result of the vibration of the blades but without the strand coming into contact with the blades.

I have found that while the motion of the blade support may be induced and regulated very readily by external means of common knowledge to agree with the blade vibration vibrations in the blades are induced as a result of their inertia in conjunction with the inertia of the fluid in the area between the blades.

I have found under proper dimensional conditions and with suitable control of applied power and fluid supply all readily to be had thru the use of well known apparatus that this flow may be made to take place along the area bounded by the adjacent faces of the blades irrespective of the angle to the horizontal at which the blades and blade faces are operated so that if the blades are vertically positioned with their free ends upwards and fluid introduced between them at their lower or fixed ends the flow may be caused to take place upwards against the force of gravity. I have found also that fluid treating solutions such as are used with a strand in all common viscosities and specifically up to 300 Saybolt-Furol seconds can be elevated as described and if enough power is applied these solutions may be broken up in the area near the blade tips by mixture with air into turbulent masses better adapted for the purpose of superimposition on strands than the parent static solution, the apparent reduction in true viscosity being due to aeration. I have also found that by operating adjustment fluids can have the character of their mass/volume ratio changed in the blade tip area to appear as a substantially sustained and contained field of spaced columnar shaped fluid particles extending across the blade area in a matrix formation interspersed with violently reciprocating loose particles or drops and that the size and spacing of the particles diminishes with an increase in frequency. I have also found that if such a field is formed in balance against gravity that it will remain in sustained reciprocation indefinitely so long as the particles flung off from the edges are replaced except for evaporation or thixotropic effects. I have found also that a strand passed thru this field for treatment will receive a beneficial kinetic energy from the moving fluid resulting in acceleration of a permeating or coating effect and that the upward flow of fluid wave form existing between the blades is sufficiently fast so that at all ordinary processing speeds the upward flow will replenish the treating area at a rate in agreement with the drawing away of fluid by the strand so that by controlling externally the incoming fluid supply or the power or both a regulation of the amount of superimposed fluid may be attained. To assist this control the blades may be variously shaped to increase or decrease the length of the treating area as illustrated thereby altering the time of treatment. In the above operations the space between the blades may be made sufficiently wide so that there is no physical contact between the vibrating blades and the strand which could produce friction or abrasion.

I have found furthermore that the impact of particles on the strand seems to be balanced across the strand axis in practice so that a condition of operation may be readily attained where no considerable unbalanced stresses are applied to the strand by the fluid tending to force it from its natural path altho actually the strand continually receives variable and alternating pressures from the reciprocating field sufficient to noticeably accelerate a treating action and stimulate cross-sectional fluid flow in and around a strand and the strand elements but without causing undue strand vibration or causing rupture of the fibres. The same beneficial effect of a substantially balanced cross-sectional pressure occurs even though the flow is not dispersed in suspension beyond moderate turbulence. It is to be understood that there is a continual throwing off of particles from the blade ends and edges but not enough to affect the attainment of a substantially constant and stable mass/volume ratio of reciprocating fluid sustained and elevated in a treating area apart from

a fluid supply area as a primary result of the blade action on the fluid.

I have found furthermore that where a portion of the blades near their fixed ends are immersed in a fluid reservoir as a means of supplying with fluid treating areas between the blades, amplitudes of the immersed blade areas and the blade support need be very slight such as from five to ten one-thousandths of an inch in order to produce sufficient excitation of the free ends of the blades to satisfactorily elevate fluid for a wide range of treatments. Under such conditions the blade tips may vibrate thru an amplitude of thirty to sixty one-thousandths of an inch producing high turbulence or dispersal in the treating area but only negligible turbulence or agitation in the fluid supply reservoir. Flow has been observed under such conditions with blades spaced up to one quarter inch and under other conditions up to three-eighths inch. I have found also that fluid injected between the blades will flow and act in the same manner as though it were drawn from a reservoir by the blade action.

It is to be understood that the flow of liquid from the blade area to the strand may be optionally regulated by structural dimensions, fluid supply injector pressure, fluid reservoir level, depth of blade immersion, the physical characteristics of materials and solutions and by varying frequency, amplitude and applied power in the exciting arrangement. In operative practice delivery of fluid to a strand in a treating area may be as a substantially laminar flow, a turbulent flow, or a flow of dispersed particles as the treating operation may require altho in all cases the fluid will exert harmless reciprocating pressures on the strand substantially at right angles to the direction of flow along the area between the blades.

To utilize these features and discoveries in attaining the objects of the invention I have produced structures as in Figs. 1 and 9. In Figure 1, I show parallel spaced resilient blades 10—10' fixed to a plate 11 mounted on a blade support 12 which extends thru a resilient fluid pressure seal ring 13 located in the bottom of a reservoir 14 and fastened to a housing 15 attached to an electric motor 16 which is pivotally mounted at 17—17 to a frame 18 which rigidly supports reservoir 14 and is rigidly attached to a base 19. To the motor shaft 20 is attached a weighted arm 21 unbalanced with regard to the motor shaft. A removable cover 22 is provided for reservoir 14 and an optional fluid injector supply pipe or flexible supply line 24 by which fluid may be optionally injected between the blades by a convenient and common fluid circulating apparatus. The location of supply pipe 24 is entirely optional. Connecting pipes 25 are provided on reservoir 14 by which fluid level in the reservoir may be controlled or drawn off as desired in conjunction with any convenient fluid control apparatus not shown.

In operation of the device motor shaft 20 is caused to revolve by current from an electrical supply line 26 and to rotate arm 21 whose centrifugal force causes oscillation of motor 16 on pivots 17—17 in an amplitude controlled by the resilience of seal ring 13 and which is required to be on the order of five to ten one-thousandths of an inch for general operation and is not enough to cause leakage at the seal under ordinary conditions. A schematic enlargement of this amplitude together with the associated reciprocating curvilinear motion of mean point O on the axis of blade support 12 and related blade deflections as shown in Fig. 3 where points A and B are the limits of blade support motion. The general arrangement is that of an electromechanical vibrating system where the period of the exciting force, which is in this case the period of one shaft revolution, is made to agree with the period of natural blade vibration as modified by fluid load. For heavy work seal ring 13 may be replaced by a metal bellows 40 as shown in Fig. 12 and resilient stops for limiting the oscillation of motor 16 added as optionally required.

Under the conditions described rotation of shaft 20 will thru the associated parts induce vibrations in blades 10—10' which will sustain fluid injected between the tips in the vicinity of their free ends to form a treating area thru which a strand may be passed or will elevate and sustain fluid with the fluid supplied at a point below the treating area. Under ordinary operating conditions fluid elevation is readily attained for the purpose described thru a vertical distance equivalent to sixty per cent of the free blade length.

It is to be understood that the presence of fluid between the blades will dampen or slow up the period of blade vibration with relation to the period of the unloaded blade and that this must be considered in synchronizing the blade support vibration with the blade vibration.

When blades 10—10' are vibrated in the manner described fluid injected in the vicinity of the blade tips as thru pipe 24 may be sustained and immediately thrown into turbulent reciprocation or into a reciprocating field of dispersed particles as a result of impact with the blades so that a strand 27 passing thru clearance slots in reservoir 14 as at 28 and between the blades may receive an energetic superimposition of fluid without coming into physical contact with any part of the treating apparatus. Under these conditions fluid will be drawn off by the strand at a rate which may be controlled by varying the rate of flow thru pipe 24 and a negligible amount of fluid will be flung from the blades and drop to collect in reservoir 14 where it may be optionally disposed of thru pipes 25.

It is to be understood in the action described that sufficient clearance is provided between the adjacent blade faces so that their motion does not cause them to touch the strand. Specifically, a strand one sixteenth inch in diameter may pass thru blades spaced one quarter inch apart and be energetically treated by reciprocating fluid without coming into physical contact with the blades.

As fluid treating apparatus for strands is generally used in series with common forms of apparatus such as supply and take-up creels and winders usually equipped with strand positioning guides which can conveniently position the strand for the fluid treatment described, no positioning guides are shown altho it is to be understood that any of the common forms may be optionally used with this apparatus. In case there is an excess deposit of fluid any suitable form of common stripping means may be used but if the apparatus is properly dimensioned and regulated for a specific operation of superimposing fluid on a strand a sufficiently close control of flow from the fluid supply thru the blades to the strand may be attained to make such stripping means unnecessary.

Fluid flow in wave form may be obtained in

reservoir 14 having fluid level 29 for supply purposes with this important and distinct difference in contrast with previous fluid wave generating arrangements that the tandem arrangement of blades is upended or positioned with their free ends extending above the fluid level, vibration of the blades then acting to raise the fluid in the area between the blades above its normal level.

The form of fluid wave generator shown schematically in Fig. 1 is a new and most useful means of fluid processing textile strands in continuous motion at high speeds and its properties are the principal features of this invention. With a normal liquid level in reservoir 14 as at 29 and blades 10—10' partly immersed as indicated, the blades will under proper conditions of operation cause the liquid level to rise in the areas between the blades 10—10' until it is well above the normal level shown at 29 in the area bounded by the free ends of the blades. While capillary action may be present between the fluid and blades 10—10' it is only slightly responsible for the rise in level observed, which if the imparted energy is sufficient will travel to the limit of the vibrating blades and be dispersed violently in drops while a continuous flow of fluid in wave form travels upwards between the blades. A lesser amount of energy will cause the liquid to stand balanced against the action of gravity at a fixed level, with the greater part of the liquid being retained between the blades in reciprocating suspension. In either case the flow of liquid up the blades is a function of the amplitude, frequency and energy of oscillation of blade support 12 and the resilience, shape and character of blades 10—10' together with the temperature, weight and viscosity of the fluid the flow persisting in the presence of wetting agents normally producing low surface tension and a reduction in capillary attraction. When the blade vibration ceases the liquid drops back to normal level as at 29.

The fluid wave generation causing a flow or a controllable rise in the fluid between blades 10—10' permits horizontal textile strands to pass across the fluid reservoir and make contact only with the fluid wave rising between the blades 10—10' which is a most valuable feature.

The traverse of a textile strand thru a fluid area such as that elevated between blades 10—10' by oscillation where the fluid is violently agitated is of benefit in many fluid processing operations this action tending to accelerate the fluid treatment of strands by promoting an exchange of fluid in a strand for a fresh portion of treating fluid, to break crystals or particles which have gone out of solution or to displace formations of gas bubbles which tend to cling to the fibre and interfere with a gassing action.

In like manner a fluid wave may be generated in an electrolyte such as acid copper sulphate to cause flow against a metallic strand for electroplating purposes.

Figs. 5 and 6 show in schematic profile types of blades which can be used to reduce the dimensions of treating areas as at 40 with respect to a common dimension at the point of attachment to blade support 12 as an aid in controlling the rate of fluid superimposition while in Figs. 7 and 8 the profile is extended as at 41 and 42 for increasing the treating area.

A type of this invention differing from Fig. 1 in that the blade support 33 has linear rather than curvilinear reciprocation is shown in Fig. 9 where blade support 33 traverses reservoir 30 and is mounted in leakproof resilient mountings 31, oscillation of blade support 33 being effected by an armature coupled to shaft 33 at 35, a solenoid 36, and adjustable balance springs at 37 whereby blade support 33 and blades 34 become components of an electro-mechanical vibrating system responsive to common forms of alternating current. The approximate operating level of fluid in reservoir 30 is shown at 39.

In Figs. 10 and 11 there is shown schematically the linear motion of blade support 33 and the associated deflections of blade 34, the result of this linear reciprocation being substantially the same as that produced by the curvilinear reciprocation except that this type is structurally better adapted for use in the fluid treatment of multiple closely spaced strands running in parallel as on a storage reel or in a flat warp.

It will be readily comprehended that by proper design and proportioning of the parts with relation to desired flow and operating speed of the components a useful and considerable fluid flow of wave form may be set up in a fluid and useful changes in the character of the fluid flow effected.

It is to be understood that many other fluid processing operations may be carried out by the devices and methods described without departing from the spirit and scope of the invention as claimed.

It is to be understood also that many other common and well known means of actuating the blade and blade support arrangement described to attain the synchronized vibration necessary realizing the objects of this invention with this apparatus may be optionally used for the purpose but that such usage does not avoid the spirit and scope of the invention as claimed.

While the best condition of operation is probably attained when the blade support oscillation has the same frequency as the loaded blade frequency, slight differences in frequency can occur without other effect than a slight reduction in the efficiency of the device. Under certain conditions the blade support could operate at a harmonic frequency and reduce a certain amount of vibration in the blades at their natural frequency. By an agreeable frequency is meant a frequency whose result will be to actuate the blades at their natural frequency to a degree which will produce the result described as a dispersed reciprocating fluid particle field.

It is believed that the discovery that treating fluids may be manipulated to be usefully contained, reciprocated for the purpose of obtaining fluid pressure and sustained against the action of gravity in a treating area in the manner described has broad usefulness in strand treatments as a means of stimulating fluid flow around or thru the strand section without damage.

I claim:

1. Apparatus for the fluid treatment of strands or the like which comprises a fluid container, a pair of upright generally parallel resilient blades disposed in said container, fluid supply means for maintaining treating fluid in said container at a level below the upper ends of said blades, means for passing strand to be treated between the protruding ends of said blades, a shaft to which the lower ends of said blades are rigidly attached below said liquid level and means for vibrating said shaft in a direction generally normal to the planes of said blades at a fre-

quency corresponding to a natural frequency of the same, said blades being so spaced apart that a vibrating field will be produced between their adjacent faces for raising fluid therebetween at least to the level of the path of strand level independently of any capillary action.

2. Apparatus in accordance with claim 1 in which said shaft is vibrated in a curvilinear path generally normal to the planes of said blades.

3. Apparatus in accordance with claim 1 in which said fluid supply means includes a conduit having an outlet above said blades.

4. Apparatus in accordance with claim 1 in which the amplitude of vibration of said shaft is of the order of five to ten one-thousandths of an inch and of the tips of the blades thirty to sixty one-thousandths of an inch, at frequencies of the order of eighty to three hundred cycles per second, said blades being less than ¾" apart.

5. Apparatus in accordance with claim 1 in which said means for vibrating said shaft includes a rotating shaft and an eccentric weight on said rotating shaft.

6. Apparatus for the fluid treatment of strands or the like which comprises a fluid container, a series of upright generally parallel resilient blades disposed in said container, fluid supply means for maintaining treating fluid in said container at a level below the upper ends of said blades, means for passing strands to be treated between the protruding ends of said blades, a shaft to which the lower ends of said blades are rigidly attached below said level and means for vibrating said shaft in a direction generally normal to the planes of said blades at a frequency corresponding to a natural frequency thereof, said blades being so spaced apart from each other that vibrating fields will be produced between their adjacent faces for raising fluid therebetween at least to the level of the paths of strand travel independently of any capillary action.

7. Apparatus in accordance with claim 6 in which said shaft is vibrated in a linear path.

8. Apparatus in accordance with claim 6 in which the amplitude of vibration of said shaft is of the order of five to ten one-thousandths of an inch and of the tips of the blades thirty to sixty one-thousandths of an inch, at frequencies of the order of eighty to three hundred cycles per second, said blades being less than ¾" apart.

9. Apparatus in accordance with claim 6 in which said means for vibrating said shaft includes a solenoid actuated by alternating current at the desired frequency and a lever system connected to said shaft.

10. Apparatus in accordance with claim 1 in which the protruding ends of said blades are extended in planes parallel to the path of strand travel for extending the length of said vibrating field.

11. In apparatus for use in a fluid processing operation, means for producing a field of rapidly reciprocating fluid particles in a desired processing area which comprises at least one pair of generally parallel resilient blades, a driving member to which said blades are rigidly attached, mechanism for vibrating said member, and means for supplying fluid to the area between said blades, the points of attachment of said blades to said member being spaced from the centers of lateral resistance to motion of said blades and the frequency and mode of vibration of said mechanism and member being such as to vibrate said blades in a direction generally normal to their planes at a frequency corresponding to their natural frequency taking into account the inertia of the fluid in contact therewith, whereby said fluid will be dispersed into a field of particles rapidly reciprocating between said blades and tending to travel in the direction of their free ends independently of any capillary action, the area near said free ends and between the same constituting said processing area.

12. In apparatus for use with a process for fluid treating a continuously moving material, means for producing a field of rapidly reciprocating particles of treating fluid in a desired treating area which comprises at least one pair of generally parallel resilient blades, a driving member to which said blades are rigidly attached, mechanism for vibrating said member, means for supplying treating fluid to the area between said blades, the points of attachment of said blades to said member being spaced from the centers of lateral resistance to motion of said blades and the frequency and mode of vibration of said mechanism and member being such as to vibrate said blades in a direction generally normal to their planes at a frequency corresponding to their natural frequency taking into account the inertia of the fluid in contact therewith, whereby said fluid will be dispersed into a field of particles rapidly reciprocating between said blades and tending to travel in the direction of their free ends independently of any capillary action, the area near said free ends and between the same constituting said treating area, and means for passing the material to be treated through said area.

13. In apparatus for use in a fluid processing operation, means for producing a field of rapidly reciprocating fluid particles in a desired processing area which comprises at least one pair of generally parallel resilient blades, a driving member to which said blades are rigidly attached, mechanism for vibrating said member, and a fluid container in which said blades are partially immersed, the points of attachment of said blades to said member being spaced from the centers of lateral resistance to motion of said blades and the frequency and mode of vibration of said mechanism and member being such as to vibrate said blades in a direction generally normal to their planes at a frequency corresponding to their natural frequency taking into account the inertia of the fluid in contact therewith, whereby said fluid will be raised between said blades and dispersed into a field of particles rapidly reciprocating therebetween and tending to travel in the direction of the free ends thereof independently of any capillary action, the area near said free ends and between the same constituting said processing area.

14. In apparatus for use with a process for fluid treating a continuously moving material, means for producing a field of rapidly reciprocating particles of treating fluid in a desired treating area which comprises at least one pair of generally parallel resilient blades, a driving member to which said blades are rigidly attached, mechanism for vibrating said member, a fluid container in which said blades are partially immersed, the points of attachment of said blades to said member being spaced from the centers of lateral resistance to motion of said blades and the frequency and mode of vi-

bration of said mechanism and member being such as to vibrate said blades in a direction generally normal to their planes at a frequency corresponding to their natural frequency taking into account the inertia of the fluid in contact therewith, whereby said fluid will be raised between said blades and dispersed into a field of particles rapidly reciprocating therebetween and tending to travel in the direction of the free ends thereof independently of any capillary action, the area near said free ends and between the same constituting said processing area, and means for passing the material to be treated through said area.

PYAM L. PENDLETON.

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