United States Patent

Means

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[54] STOCK FLOW SYSTEM FOR PAPER-MAKING MACHINE

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[52] **U.S. Cl.** **162/216,** 162/336, 162/343

[51] **Int. Cl.** **D21f 1/06**

[58] **Field of Search** 162/212, 216, 343, 336

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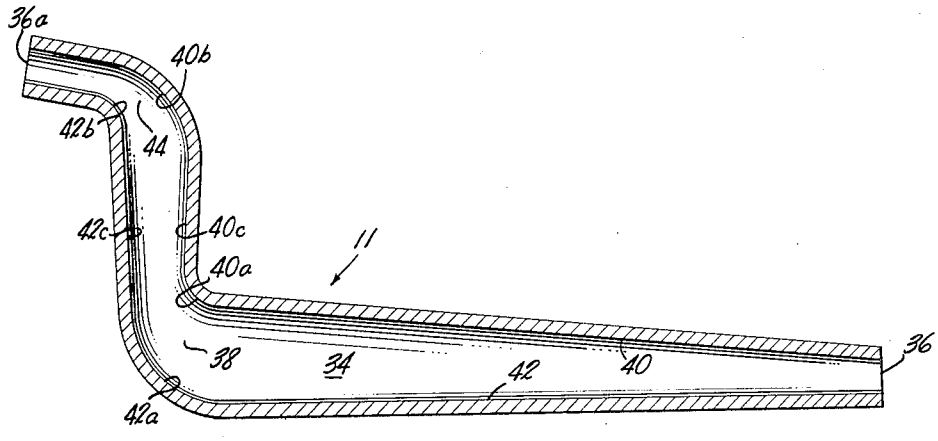
[57] **ABSTRACT**

In order to establish diffusion among a plurality of fluid streams emanating respectively from a plurality of conduits in parallel, closely-spaced-apart relation, the streams are combined within a single enclosure to form a single stream of substantial width compared to its thickness. The enclosure is formed with a double elbow so that the direction of movement of the stream is changed twice in succession, through an angle of substantially 90° in each case. The enclosure is formed in the vicinity of each elbow in such a manner as to cause acceleration of the stock during each change in its direction of movement and deceleration of the stock immediately preceding each change in its direction of movement.

10 Claims, 5 Drawing Figures



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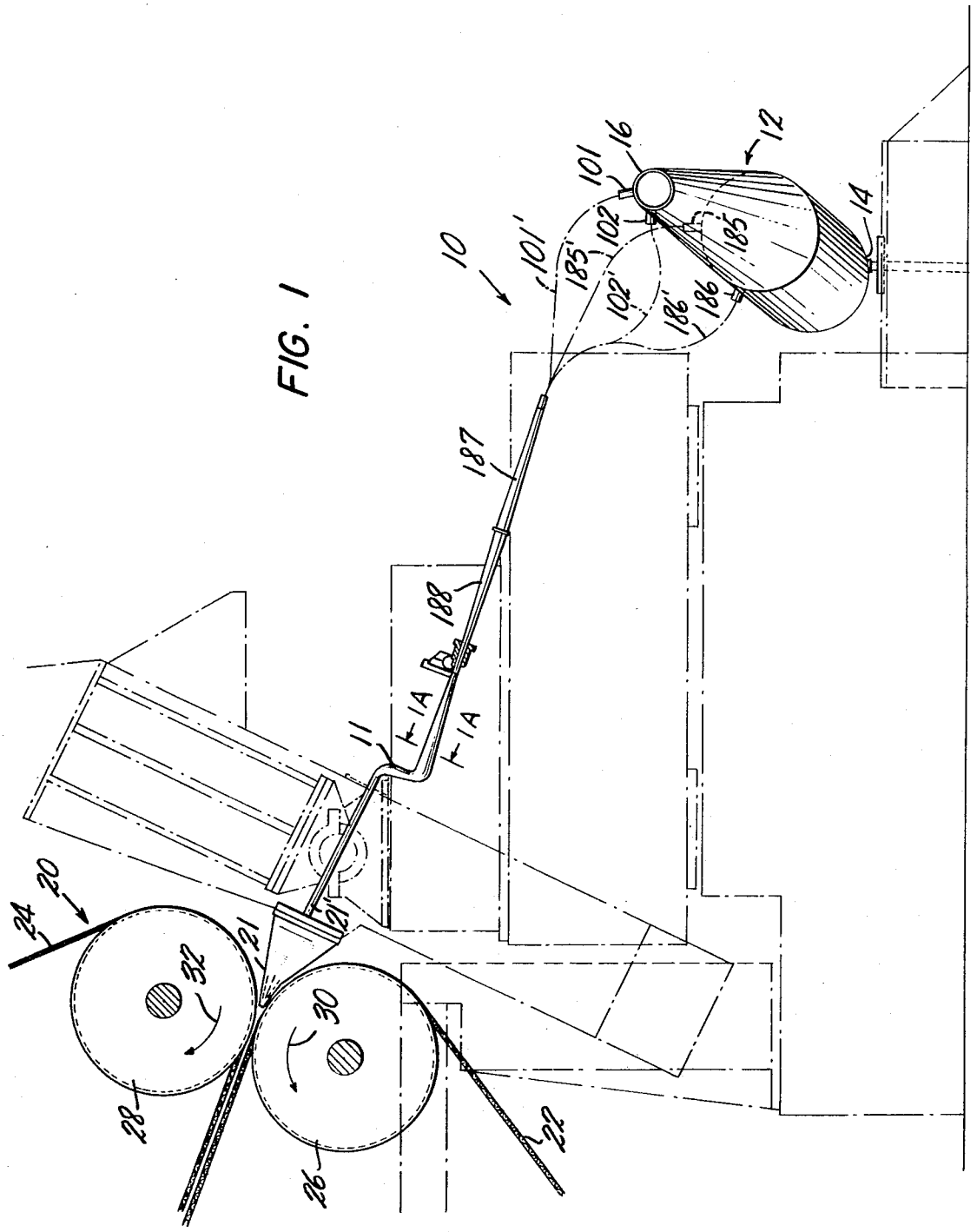
2 Sheets-Sheet 1

FIG. 1



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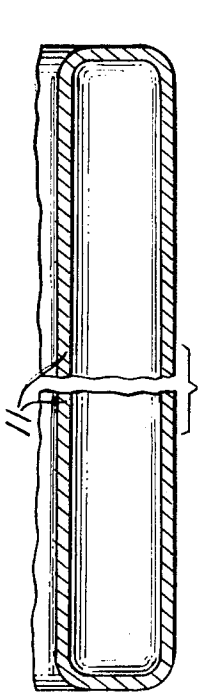

FIG. 1A

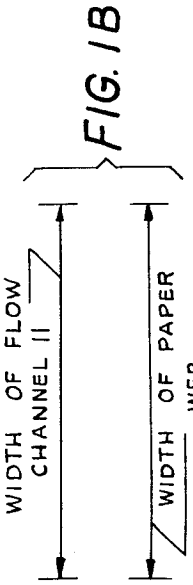

FIG. 1B

FIG. 3

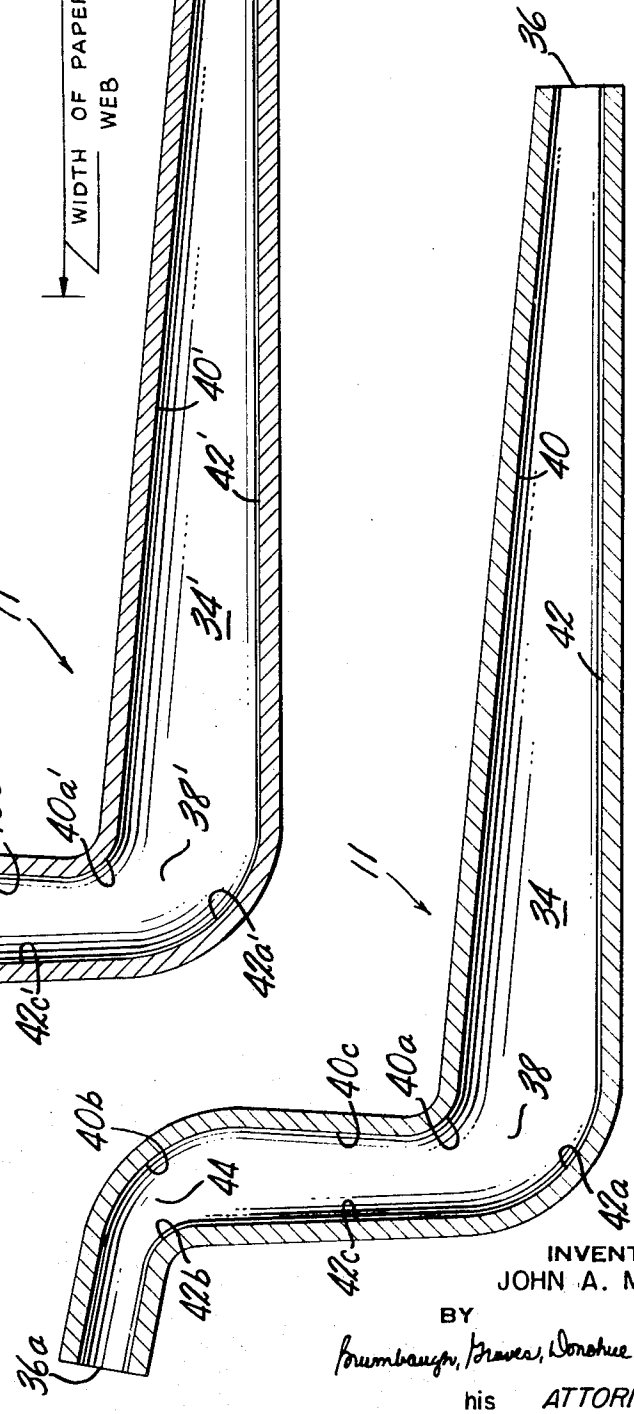

FIG. 2

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STOCK FLOW SYSTEM FOR PAPER-MAKING MACHINE

BACKGROUND OF THE INVENTION

This invention relates to flow systems for paper-making machines and, more particularly, to novel and highly-effective methods and apparatus facilitating the establishment of diffusion among a plurality of streams of paper stock emanating respectively from a plurality of hoses, tubes or other fluid conduits or flow channels in parallel in such a manner as to remove the raw stock cross-machine basis-weight variations that depend on the geometry of the fluid conduits, without diminishing the integrity and stability of the jet of stock supplied to the wet end.

Some of the most advanced paper-stock flow systems that have been constructed heretofore include a plurality of hoses or other fluid conduits mounted in parallel for establishing a plurality of streams of stock that are combined into a single wide, flat stream a relatively short distance upstream of the nozzle. Such machines are greatly superior in many ways to earlier flow systems. For example, flow systems including the parallel conduits have relatively little tendency to accumulate growths of slime. Moreover, control of cross-machine basis-weight variations is facilitated by adjustments that can be made individually to the conduits.

Notwithstanding these advantages, however, there remain in the best flow systems heretofore available residual variations in basis weight that depend on the geometry of the conduits. Even with the closest quality control the conduits are inevitably slightly different from one another. These differences relate to cross-sectional flow area and shape at various points along the lengths of the conduits, to the degree of smoothness of the interior surfaces of the conduits, to differences in the ages and length of use of the conduits, and to differences in the curves described by the conduits. Moreover, even if the conduits were identical in every respect, there are still small differences in the characteristics of the stock transported by the conduits, notwithstanding efforts to supply the conduits with stock that is completely homogeneous. Also, there are velocity and consistency gradients, discussed below, that would exist irrespective of differences among the conduits.

The streams in the conduits must be combined into a single relatively wide, flat stream prior to ejection of the stream as a jet from the flow system nozzle onto a permeable wire or between a pair of permeable wires, for the formation of a web of paper. In order to obliterate any longitudinal streaks that might otherwise appear in the resulting web of paper at the boundaries of the streams from the conduits, it is necessary to establish diffusion of these streams.

Proposals heretofore made for accomplishing this result include the provision of a flat channel with or without stock-flow-obstruction means, venturi shapings and other expedients. While certain of these prior expedients have improved the quality of paper that can be manufactured, they have not been a complete solution to the problem.

SUMMARY OF THE INVENTION

An object of the invention is to remedy the difficiencies of conventional methods and apparatus noted above. In particular, an object of the invention is to establish diffusion among a plurality of fluid streams emanating respectively from a plurality of tubes, hoses or other fluid conduits in parallel, closely-spaced-apart relation in such a manner as to remove the raw-stock cross-machine basis-weight variations that depend on the geometry of the conduits, without diminishing the stock jet integrity and stability. Another object is to improve the quality of the formed sheet.

The foregoing and other objects of the invention are attained by combining the streams within a single enclosure to form a single stream of substantial width compared to its thickness, changing the direction of movement of the single stream twice in succession through angles each within the range of 80° to 100°, and accelerating the single combined stream during each of the changes in direction of movement.

The stream is decelerated immediately preceding each of the changes in direction of movement.

BRIEF DESCRIPTION OF THE DRAWING

An understanding of additional aspects of the invention can be gained from a consideration of the following detailed description of a representative embodiment thereof, in conjunction with the appended figures of the drawings, wherein:

FIG. **1** is a fragmentary view in side elevation of a preferred embodiment of apparatus constructed in accordance with the invention;

FIG. **1A** is a broken schematic cross-sectional view, on an enlarged scale, taken along the line **1A—1A** of FIG. **1** and looking in the direction of the arrows;

FIG. **1B** is a diagram comparing the width of a portion of the apparatus of FIGS. **1** and **1A** to the width of a paper web made by means including such apparatus;

FIG. **2** is a sectional view in side elevation, on a larger scale than FIG. **1**, of a portion of the apparatus of FIG. **1**; and

FIG. **3** is a sectional view in side elevation of another embodiment of the portion of the apparatus shown in FIG. **2**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The figures show a paper stock flow system **10** including a portion **11** thereof with which the present invention is particularly concerned. The flow system **10** comprises a header **12** having an upstream end **14** of large diameter, a downstream end **16** of small diameter, open to permit recirculation of a portion of the stock supplied to the header **12**, and a plurality of stock delivery openings **101–186** between the downstream end **16** and the upstream end **14**. For clarity, most of the openings **101–186** are omitted from the drawing.

The portion **11** of the flow system **10** is a single enclosure provided for delivering the paper stock to a paper-making machine **20** that forms the stock into a paper web. The enclosure **11** is formed with an unobstructed flow channel and may communicate with or include any suitable nozzle or slice **21** for ejecting the stock between forming wires or permeable belts **22** and **24** respectively wound about rolls **26** and **28** or other training means. A flat channel **21'** may be mounted between the portion **11** of the flow system **10** and the nozzle or slice **21**. The rolls **26** and **28** and the wires or belts **22** and **24** respectively rotate and move as shown by arrows **30** and **32** to receive and transport a jet of stock and form it into a paper web. The flow channel **11** is undivided in the sense that it is substantially as wide as the stock stream delivered to the paper-making machine **20** (see FIG. **1B**), and it is possible to trace a continuous path through the channel **11** from one edge to the other in a direction generally normal to the plane of FIG. **1**, all points of such path lying in the path of stock flow.

The apparatus **10** also includes a plurality of flow channels **101'–186'** in parallel with one another and collectively in series with the undivided flow channel **11** and the header **12**. For clarity, most of the flow channels **101'–186'** are omitted from the drawings. Each flow channel of the flow channels **101'—186'** in parallel with one another is connected at its downstream end to the undivided flow channel **11** and at its upstream end to a separate one of the openings **101—186** on the header **12**.

Each of the flow channels **101'—186'** includes an upstream portion made of flexible hose or the like, shown schematically in dash-dot outline in FIG. **1**, and connected to the header **12**. Each flow channel also includes an expansion pipe similar to the expansion pipe **187** connected to the associated flexible hose. Each flow channel includes, finally, a spreader pipe **188** of changing cross-section. The expansion pipes **187** have progressively increasing cross-sectional flow area in the direction of stock flow in order to decelerate the stock, and the spreader pipes **188** of changing cross-section have cross-sectional shapes that change from circular where they are connected to the expansion pipes **187** to rectangular where they are connected to the unobstructed flow channel **11**. The pipes

188 of changing cross-section have slightly decreasing cross-sectional flow areas in the direction of stock flow, so that stock flowing therethrough is accelerated slightly.

Certain features of the flow system **10** described above are disclosed and claimed in my co-pending application Ser. No. 816,894 filed Apr. 17, 1969 for "Tapered Header" and in a co-pending application of Means et al. Ser. No. 702,101 filed Jan. 31, 1968, now Pat. No. 3,628,589, for "Flow Systems." These aspects of the flow system **10** disclosed herein are claimed only in the respective earlier-filed applications and per se do not constitute the present invention and are not claimed herein.

The present invention is concerned particularly with the structure of the double-elbow portion **11**, shown in detail in FIG. **2**, of the flow system **10** and its cooperation with the separate flow channels **101'–186'** to establish diffusion among the fluid streams emanating from those channels.

The problem that is solved arises from several phenomena. First, there are differences in the conduits and in the stock supplied to the conduits. Second, the flow velocity in each of the conduits in parallel upstream of the portion **11** is relatively low near the conduit walls and higher in the center of the conduit. This velocity gradient in each conduit is due to friction with the conduit walls. Third, there is a nonuniform distribution of fibers in the flow stream, a higher concentration or consistency occurring in higher-velocity areas and a lower concentration or consistency occurring in lower-velocity areas. Thus, the stream issuing from each conduit, whether circular or rectangular at its exit, has a core of higher relative flow volume per unit of time, with increased kinetic energy, and is characterized by the further exaggeration that the core has relatively higher consistency. These individual high-velocity, high-consistency cores must be diffused with the remainder of the stock emanating from the respective conduits and additionally, to the extent practicable consistently with the need to maintain the integrity and stability of the jet of stock supplied to the wet end, the stock emanating from each conduit must be diffused with the stock emanating from adjacent conduits.

The method of the invention comprises the steps of combining the streams emanating from the respective channels within the single enclosure **11** to form a single stream **34** flowing where combined substantially in the same direction as the structure in the pipes **188** (FIG. **1**) and of substantial width compared to its thickness (FIG. **1A**). The width of the stream **34** is in fact substantially equal to the width of the paper web made on the paper-making machine **20**. The thickness of the stream **34**, on the other hand, is about an inch in a typical case at the upstream end **36** thereof and about 3 inches immediately upstream of a first elbow portion **38**, so that the ratio of flow speed immediately upstream of the elbow **38** to flow speed at the upstream end **36** is about ⅓. The deceleration of the stock between the entrance **36** and the first elbow **38** can readily be effected over a length of some 21 inches. The distance of 21 inches is not critical per se, the important consideration being that it be long enough so that the included angle between opposite walls **40** and **42** is between 0° and 6°. An angle substantially larger than 6° tends to be accompanied by counterflow instability.

Downstream of the first elbow **38** is a second elbow **44**. The elbows **38** and **44** change the direction of movement of the stream **34** twice in succession through angles each within the range of 80° to 100° and preferably substantially 90°.

In accordance with the invention, the stock is accelerated throughout each of the changes in direction of movement at the elbows **38** and **44** by construction of the walls in such a manner that the cross-sectional flow area of the stock is reduced at the elbows. In this way, stability of flow is maintained in the elbows. The ratio of the cross-sectional flow area of the stock immediately upstream of the first elbow **38** to the cross-sectional flow area of the stock immediately downstream of the first elbow **38** is substantially 12/7. The corresponding ratio for the second elbow **44** is comparable, being substantially 17/8. These ratios are attained without disrupting stock flow by proper selection of the radii of curvature of the elbow wall portions. The wall portion **40*a***, for example, may have a radius of curvature of 1⅛ in., while the wall portion **42*a*** has a radius of curvature of 3 in. Similarly, the wall portion **40*b*** may have a radius of curvature of 3 in., while the wall portion **42*b*** has a radius of curvature of 1⅛ in.

The speed of movement of the unified stream **34** at the point **36*a*** immediately after the second of the changes of direction, effected by the elbow **44**, is the same as the speed of movement of the stream upstream of the end **36**.

The direction of movement of the unified stream **34** immediately after the second of the changes therein, effected by the elbow **44**, is substantially parallel to the direction of movement of the stream immediately before the first of the changes therein, effected by the elbow **38**. However, as FIG. **3** shows, it is also within the scope of the invention to provide a double-elbow portion **11'** that causes the second change in direction of movement to be in the same sense (i.e., clockwise from the perspective of FIGS. **2** and **3**) instead of in the opposite sense. FIG. **3** employs the same reference characters as FIG. **2**, with the addition of primes. In this embodiment, the direction of movement of the stream immediately after the second of the changes therein, effected by the elbow **44'**, is substantially opposite to the direction of movement of the stream immediately before the first of the changes therein, effected by the elbow **38'**.

Between the two changes in direction of movement effected by the elbows **38** and **44**, respectively (FIG. **2**), or **38'** and **44'**, respectively (FIG. **3**), the stock is decelerated. This is effected by the divergence from each other of opposite wall portions **40*c*** and **42*c*** (FIG. **2**) and **40*c'*** and **42*c'*** (FIG. **3**). Again, the included angle of expansion must be between 0° and 6°. The total deceleration immediately upstream of the elbow **44** is less than the earlier deceleration immediately upstream of elbow **38**. As noted above, such earlier deceleration immediately upstream of the elbow **38** reduces stock velocity to ⅓ of the velocity at the point **36**.

The through-put of the stream **34** (FIG. **2**) or **34'** (FIG. **3**) is within the range of 30 to 60 gallons per minute per inch of width of the stream.

Thus there is provided in accordance with the invention novel and highly effective methods and apparatus facilitating the diffusion of streams from individual hoses, tubes or other fluid conduits or channels in a multiple stream system in such a manner as to remove the raw-stock cross-machine basis-weight variations that are tube-geometry dependent. The result is an improvement in formed sheet quality. In accordance with the invention it is possible to distribute the flow from a spreader **188** having a downstream end 3 in. wide (in a direction normal to the plane of FIG. **1**) uniformly over a width of 7 in. The flow tapers off in directions normal to the plane of FIG. **1** over an additional 1.5 in. at either limit of the 7 in. so that a distribution over a total width of 10 in. is achieved. This results in very good mixing of the stock from one spreader with the stock from two adjacent spreaders and partial mixing with the stock from the next two adjacent spreaders. The flow from one spreader is thus diffused over a width otherwise serviced by five spreaders. Similar results are obtained in the case of spreaders having exits of other widths, for example 4 in.

Many modifications of the representative embodiments disclosed herein will readily occur to those skilled in the art. Accordingly, the invention is to be construed as including all the modifications thereof within the scope of the appended claims.

I claim:

1. A method of establishing diffusion among a plurality of streams of paper stock emanating respectively from a plurality of fluid conduits in parallel, closely-spaced-apart relation, comprising the steps of combining said streams within a single enclosure to form a single stream of substantial width compared to its thickness, said single stream where combined

flowing substantially in the same direction as said plurality of streams changing the direction of movement of said single stream twice in succession through angles each within the range of 80° to 100°, accelerating said single stream throughout each of said changes in direction of movement, and decelerating said single stream immediately before each of said changes in direction of movement.

2. A method according to claim 1 wherein each of said angles is substantially 90°.

3. A method according to claim 1 wherein the direction of movement of said single stream immediately after the second of said changes therein is substantially parallel to the direction of movement of said single stream immediately before the first of said changes therein.

4. A method according to claim 1 wherein the direction of movement of said single stream immediately after the second of said changes therein is substantially opposite to the direction of movement of said single stream immediately before the first of said changes therein.

5. A method according to claim 1 wherein the ratio of the speed of said stock immediately after the earlier of said two decelerations to the speed of said stock immediately before the earlier of said two decelerations is substantially ⅓.

6. A method according to claim 1 wherein the throughput of said single stream is within the range of 30 to 60 gallons per minute per inch of width of said single stream, and further comprising the step of forming a paper web from said single stream, said web having a width substantially equal to the width of said single stream.

7. Apparatus for establishing diffusion among a plurality of parallel streams of paper stock employed in the manufacture of a paper web, comprising an unobstructed flow channel into which said streams discharge, said channel having a width substantially equal to the width of said paper web and defining a first elbow wherein stock flow direction changes through a first angle of substantially 90° and a second elbow downstream of said first elbow wherein stock flow direction changes through a second angle of substantially 90°, there being an accelerating portion throughout each of said elbows comprising converging opposite walls and wherein the cross-sectional flow area of said stock diminishes in the direction of stock flow and a decelerating portion immediately adjacent to and upstream of each accelerating portion comprising diverging opposite walls and wherein the cross-sectional flow area of said stock increased in the direction of stock flow.

8. Apparatus according to claim 7 wherein the ratio of the cross-sectional flow area of said stock immediately upstream of said first elbow to the cross-sectional flow area of said stock immediately downstream of said first elbow is substantially 12/7, and the ratio of the cross-sectional flow area of said stock immediately upstream of said second elbow to the cross-sectional flow area of said stock immediately downstream of said second elbow is comparable to said first-named ratio.

9. Apparatus according to claim 7 wherein said flow channel is formed with opposite walls diverging from each other with reference to the direction of stock flow therebetween by an included angle between 0° and 6° immediately upstream of said first elbow.

10. Apparatus according to claim 7 wherein said flow channel is formed with opposite walls diverging from each other with reference to the direction of stock flow therebetween by an included angle between 0° and 6° between said elbows.

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