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TAPERED MANIFOLD TYPE STOCK DISTRIBUTOR FOR A PAPERMAKING MACHINE

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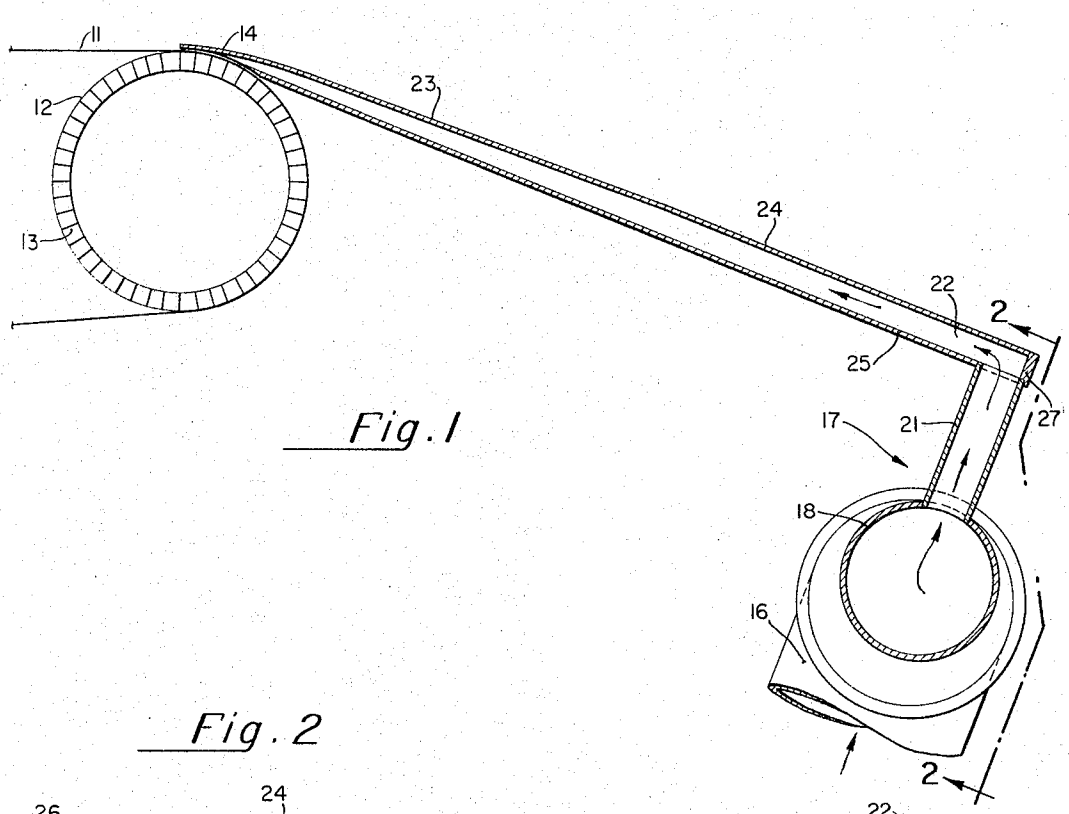
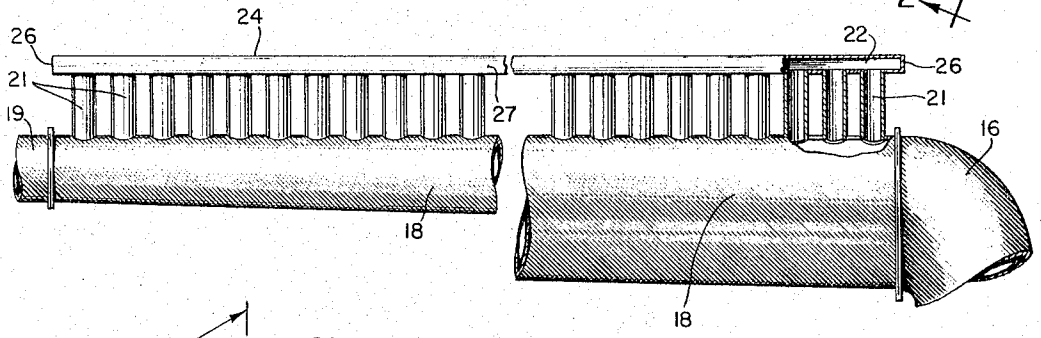


Fig. 1

Fig. 2



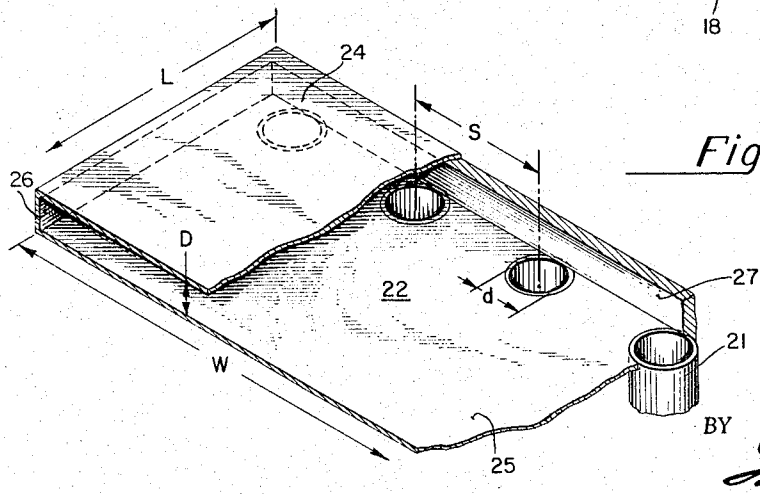


Fig. 3

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TAPERED MANIFOLD TYPE STOCK DISTRIBUTOR FOR A PAPERMAKING MACHINE

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This invention relates to fluid flow apparatus and particularly to apparatus for establishing flow having uniform velocity across the width of a relatively wide conduit or channel. Such flow is generally characterized as possessing a uniform velocity profile.

In papermaking machines, for example, there is a basic requirement for some means of transforming the flow of stock in a confined pipe into a broad, flat stream moving with uniform velocity across its width so as to produce a uniform paper web when the stock is deposited onto a moving screen. The term "flow spreader" is commonly applied to apparatus developed for the purpose of effecting this transformation of fluid flow.

A common form of apparatus in this category may employ a tapered feed distribution tube, or header, communicating with a plurality of laterals, or branch tubes, spaced along the header and communicating at their opposite ends with a blending chamber, which is sometimes referred to as an "explosion chamber." This flow spreading system functions to first divide a single large flow of relatively low velocity into a plurality of higher velocity smaller flows spaced along a common plane, which flows are thereafter blended in flow passage means of the desired final width. Such systems are in widespread use in papermaking machines, but because prior systems have been more or less imperfect, it has been necessary to employ other means, such as deceleration chambers, rectifier rolls and flow boxes downstream of the flow spreader to achieve a truly uniform stream for papermaking purposes.

This invention embodies a new concept of flow spreader design which recognizes the existence of certain critical relationships between the dimensions and disposition of the several branch tubes and the configuration and dimensions of the blending chamber associated with these tubes. As a result of this invention, it is now possible to construct flow spreading devices capable of producing a relatively wide fluid flow having a sufficiently uniform velocity profile to permit the flow of stock, for example, to be delivered directly from the flow spreader to a nozzle-type slice on a paper machine, thereby eliminating one or more elaborate flow evening devices heretofore employed between the spreader and the slice.

It can be said, then, that the principal object of this invention is improvement in the operation of fluid flow spreading devices.

A further object of the invention is simplification of papermaking machinery through the provision of improved flow spreading apparatus which eliminates a number of other components of the paper machine heretofore considered essential for proper operation.

These and other objects and advantages of the invention will be apparent from the following description thereof in which reference is made to the accompanying drawings, forming a part hereof, and wherein:

FIG. 1 is a partial view, in elevation and in section, of a papermaking machine embodying this invention;

FIG. 2 is an end view, partially in section of the flow spreader employed in the papermaking machine of FIG. 1; and,

FIG. 3 is a schematic perspective view of a portion of the flow spreader.

The papermaking machine illustrated in FIG. 1 is of the Fourdrinier type in which a traveling forming wire **11** is trained over a breast roll **12**. Stock, a mixture of water and papermaking fibers, is deposited on the upper surface of the top run of wire **11** in such a manner that the water drains through, or is drawn through, the wire and the fibers are retained on the wire in the form of a damp web. Some machines are equipped with a breast roll which has cells **13** provided in the periphery thereof to facilitate drainage of water through the forming wire. The well-known process of removing the damp paper web from the forming wire **11** and subsequently drying the web is performed by apparatus which is not shown in the drawing.

Forming wires **11** on papermaking machines may be up to 18 feet wide. If a machine is to produce a paper web of uniform thickness and appearance across its entire width, the stock delivered to the wire **11** must arrive in a stream which is flowing at an extremely uniform velocity across its width. Any variation in velocity across the width of the stream, and any cross-flow currents existing anywhere in the stream are likely to result in an uneven application of fibers to the wire **11** and the production of a non-uniform paper web.

The stock delivery system for the papermaking machine in FIG. 1 includes a nozzle-type slice **14** extending nearly the full width of forming wire **11** and designed to deposit stock onto the wire **11** substantially tangentially of the path of travel of the wire and at a velocity approximating the velocity of the wire. Stock is conveyed to the vicinity of nozzle **14** from a remotely located pump (not shown) by means of a pipe **16** which, for practical reasons, is generally circular in cross section. The relatively confined flow of stock in pipe **16** is transformed to the relatively wide and low height flow required for the nozzle **14** by means of a flow spreader indicated generally by the reference numeral **17**.

Spreader **17** includes a tapered feed distributor tube, or header, **18** communicating at its larger end with delivery pipe **16**. In accordance with conventional practice, the smaller end of header **18** communicates with a return pipe **19** through which a portion of the stock flow from pipe **16** may be recirculated to the stock mixing and pumping portion of the papermaking machine. Extending away from the tapered header **18** is a row of laterals, or branch tubes, **21** which communicate at their lower ends with upper regions of the header along the length of the header.

Branch tubes **21**, when used in conjunction with a properly designed tapered header **18**, function to divide the stream of stock into a plurality of higher velocity flows which are substantially uniform from tube to tube. The row of tubes **21** extends for a distance only slightly less than the width of nozzle **14** so that a flow can be provided of sufficient width to supply the nozzle.

Blending of the individual flows from branch tubes **21** is effected in a blending chamber **22**. It is a principal objective of this invention to provide a blending chamber **22** which is capable of developing a flow of sufficiently uniform velocity as to be deliverable directly to nozzle **14** by a simple connecting conduit **23**. Although conduit **23** may be tapered slightly, as indicated in FIG. 1, in order to accelerate the stock flowing therethrough, additional flow evening devices, such as rectifier rolls and flow boxes are not required with the flow spreader of this invention.

As indicated in FIGS. 1 to 3, blending chamber **22** is preferably rectangular in configuration and bounded by substantially flat and parallel top and bottom walls designated by numerals **24** and **25**, respectively, parallel side walls **26**, which are at right angles to top and bottom walls **24** and **25** and an end wall **27**. End wall **27** is preferably disposed at right angles to the top and bottom walls as

well as to the side walls of the chamber. It will be noted that branch tubes **21** enter the bottom wall **25** of chamber **22** in a region of the chamber adjacent end wall **27**, with the center lines of the tubes disposed approximately at right angles to walls **24** and **25** and parallel to end wall **27**. The relationship preferably is such that the flow from each tube **21** is tangent to end wall **27** of the chamber.

The stock discharged from tubes **21** impinges on the top wall **24** of blending chamber **22** and is deflected thereby, which characteristic is responsible for the term "explosion chamber" being applied to this type of blending chamber. Although the entry of stock into chamber **22** does not involve an explosive action as such, the flow area in chamber **22** is somewhat greater than the combined flow areas of branch tubes **21** so that there is a consequent deceleration of the stock flow in the chamber **22**.

This invention utilizes the discovery that a highly uniform flow can be achieved across the width of a box-like blending chamber **22** if certain critical relationships are mainained between the flow area in the chamber **22** and the flow areas and disposition of branch tubes **21**. These relationships are expressed in the following equation, which refers to dimensional factors depicted in FIGURE 3.

$$\lambda = 4SD/\pi d^2$$

wherein

λ—is a dimensionless ratio

S—is the distance between center lines of the branch tubes **21**,

D—is the depth of the blending chamber **22**, and

d—is the diameter of the branch tubes **21**.

It will be noted that the above equation λ is an expression of the ratio of the incremental flow areas in the blending chamber **22** between center lines of branch tubes **22** (SD) to the flow areas of the branch tubes **22** $(\pi d^2)/4$. Obviously, if the apparatus under consideration employed laterals having cross sections other than circular, then the equation for λ should be modified to reflect the flow area for the particular cross section used.

It has been determined that opttimum production of uniform flow in blending chamber **22** can be achieved with a λ value of approximately 1.5 and that results superior to prior flow spreading devices of this character can be achieved when λ is maintained within the range of from about 1.1 to about 1.7.

Maintaining the dimensionless ratio λ within the range given above produces the most desirable results when the space (S) between the center lines of branch tubes **21** is approximately 2.4 times the diameter (*d*) of the branch tubes. This spacing relationship is in accordance with good design practice for multiple passage flow spreaders utilizing tapered manifolds, such as manifold **18**, and provides sufficient spacing for incorporation of such fittings and welds as may be required for economical fabrication of the flow spreader. However, it has been determined that minor departures from an *S/d* ratio of 2.4, whether increasing or decreasing the ratio, have little bearing on the validity of the λ relationship and range above described and even major departures can be made in the direction of a decreasing ratio without adversely affecting performance of the flow spreader.

It is generally considered unwise to increase the spacing of the branch tubes **21** to a distance much greater than 2½ times the diameter of the tubes because this results in fewer tubes being available to convey fluid to the blending chamber **22** with a consequent increase in the velocity of flow in the individual tubes.

A practical design approach in laying out a flow spreading device incorporating this invention will generally involve first selecting those dimensions for the branch tubes **21** and their spacing (S) which in cooperation with the tapered header **18** provide the most uniform distribution of flow among the branch tubes at the desired rate of flow. As stated previously, this will generally result in an *S/d* ratio of approximately 2.4. Thereafter, a dimension for the dept (D) of blending chamber **22** is selected which when substituted in the above equation together with the values of S and D give a λ value falling within the desired range.

In one flow spreading device constructed in accordance with this invention a rectangular blending chamber having a width of 72 inches and a depth of 0.43 inch was fed from a row of 34 branch tubes of 0.875 inch inside diameter each, arranged with 2.12 inches center line spacing. The relative disposition of the branch tubes with respect to the walls of the blending chamber was essentially the same as that illustrated in the drawings. The ratio λ calculated in accordance with the above equation was 1.50, a series of velocity measurements taken across the outlet of the blending chamber, at stations 1.0 inch apart revealed maximum variations in the velocity profile from the average value of the profile of 3.0%.

Varying the depth (D) of the blending chamber of the above example between limits which has the effect of varying the ratio λ from 1.1 to 1.7 resulted in maximum variations in the velocity profile of no more than 8.0%. All of these profile variations were substantially less than those obtained with previously known blending chambers. The critical range of from about 1.1 to about 1.7 for λ is in keeping with the usual practice of providing larger flow areas in the blending chamber than in the series of branch tubes, but the ratio here given is believed to be substantially less than any range in which blending chambers of the past have been constructed. Prior to this invention it apparently has been the feeling among persons skilled in the art that the blending chamber of a flow spreading device should provide for considerably more deceleration of the stock flow than is provided by a blending chamber constructed in accordance with this invention.

Flow in blending chamber **22** is preferably maintained at Reynolds numbers in excess of 10,000 to maintain turbulent flow conditions through the chamber, as well as through delivery conduit **23** and into the nozzle **14**.

The effectiveness of blending chamber **22** is, of course, influenced to a degree by the length of the chamber (indicated by letter L in FIGURE 3) as some distance of flow must be provided for complete blending of the individual flows from branch tubes **21**. It has been found that a blending chamber constructed in accordance with the principles set forth above permits uniform blending of the flow across the width (W) of the blending chamber in a shorter distance than was heretofore believed to be practicable. In general, when the dimensionless ratio λ is maintained in the range set forth above, the length (L) of the blending chamber may be as low as 25 times the depth (D) of the chamber. Consequently, with this invention it is possible to construct a stock delivery system for a paper machine which occupies a minimum amount of space at the head, or wet, end of the machine.

Although, in the papermaking machine illustrated in the drawings, the branch tubes **21** direct their individual flows upwardly into blending chamber **22** through the bottom wall **25** of the chamber, it is to be understood that this attitude of the system is not essential to proper functioning of the blending chamber **22** or of the flow spreader generally. The system could be inverted, for example, with branch tubes **21** directed through the top wall **24** of the blending chamber **22**.

One of the desirable features of this invention is the simplicity of construction of the blending chamber portion of the flow spreader **17**. The box-like configuration for blending chamber **22** permits this portion of the flow spreader to be fabricated from sheet metal, or other sheet material, with an absolute minimum of shaping, drilling, and forming. Moreover, it is not essential to the practice of this invention that the opposing walls forming blending chamber **22** be absolutely planar and/or parallel because beneficial results can be obtained even if minor departures

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from the relationship shown and described are dictated by other design considerations.

Similarly, the flow through branch tubes **21** need not necessarily enter the blending chamber **22** in the precise manner shown and described. Although it is preferable to have fluid enter blending chamber **22** at and parallel to the rear wall **27** of the chamber, spacing the end wall rearwardly from tubes **21** by a small amount will not adversely affect operation of the flow spreader.

A further desirable feature of this invention resides in the ability of blending chamber **22** to compensate for flow velocity variations among the several branch tubes **21**. In a multiple tube system fed from a tapered header there is a tendency for the velocity of flow in the tubes near the smaller end of the header to be greater than the velocity in the tubes near the larger end of the header. A blending chamber **22** constructed in accordance with this invention will actually improve upon the distribution obtained with a well-designed multiple tube-tapered header combination.

The efficiency of the flow spreader of this invention, which, as mentioned previously, eliminates the necessity for employing additional flow evening devices, also eliminates the operational hazards commonly associated with deceleration devices, such as a tendency toward flocculation of the papermaking fibers, the development of slime and the plugging of flow passages. Furthermore, the flow spreader of this invention has very low losses associated therewith.

Although the elimination of supplementary flow evening devices is one of the principal advantages to be gained through utilization of the flow spreading system of this invention, it is to be understood that the use of this flow spreader need not necessarily be exclusive of such supplementary devices. For example, there may be instances in which the flow spreader of this invention can be incorporated into an existing papermaking machine wherein, for reasons of economy, it is not desired to remove an existing headbox and associated equipment. Incorportion of the flow spreader of this invention into such an existing system should, nevertheless, permit the flow evening capabilities of the spreader to be taken advantage of in improving overall performance of the stock delivery system.

What is claimed is:

1. Apparatus for developing in a relatively wide conduit fluid flow having a substantially uniform velocity profile across the width of the conduit, comprising a box-like blending chamber associated with said conduit and being co-extensive in width therewith, said blending chamber being defined by wall means including top and bottom walls, side walls and an end wall, and a plurality of laterals communicating through one of said top or bottom walls for admitting fluid to said blending chamber, the center lines of said laterals being substantially parallel and arranged in a plane closely spaced from said end wall, and the ratio of the flow area in said blending chamber

between center lines of adjacent laterals measured in said center line plane to the flow area in each of said laterals being in the range of from about 1.1 to about 1.7.

2. Apparatus as set forth in claim **1** wherein said ratio is of the order of 1.5.

3. Apparatus for developing in a relatively wide conduit fluid flow having a substantially uniform velocity profile across the width of the conduit, comprising a box-like blending chamber associated with said conduit and being co-extensive in width therewith, said blending chamber being defined by wall means including substantially parallel top and bottom walls, substantially parallel side walls and an end wall disposed normal to said top and bottom walls, and a plurality of equispaced tubes communicating through one of said top or bottom walls for admitting fluid to said blending chamber, the center lines of said tubes being substantially parallel and arranged in a plane closely spaced from said end wall, the apparatus satisfying the following equation: $\lambda=4SD/\pi d^2$ wherein:

S—is the distance between center lines of said tubes,
D—is the distance between said top and bottom walls,
d—is the diatmeter of said tubes,
λ—is from about 1.1 to about 1.7.

4. Apparatus as set forth in claim **3** wherein λ is of the order of 1.5.

5. In papermaking apparatus comprising a stock delivery pipe, a plurality of branch tubes communicating with said pipe for dividing at least a portion of the stock flow in said pipe into a plurality of higher velocity, smaller volume flows, said tubes being equally spaced in parallel arrangement in a common plane, means providing a blending chamber communicating with said tubes, said blending chamber being of box-like configuration and disposed to receive stock from said tubes through one wall thereof in a flow direction normal to the opposite wall of said chamber, and slice means communicating with said blending chamber, the improvement of having the flow area in said blending chamber between center lines of adjacent branch tubes measured in the plane of said tubes from about 1.1 to about 1.7 times the flow area of each of said tubes.

6. Apparatus as set forth in claim **5**, in which said flow area in said blending chamber is of the order of 1.5 times the flow area of each of said tubes.

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