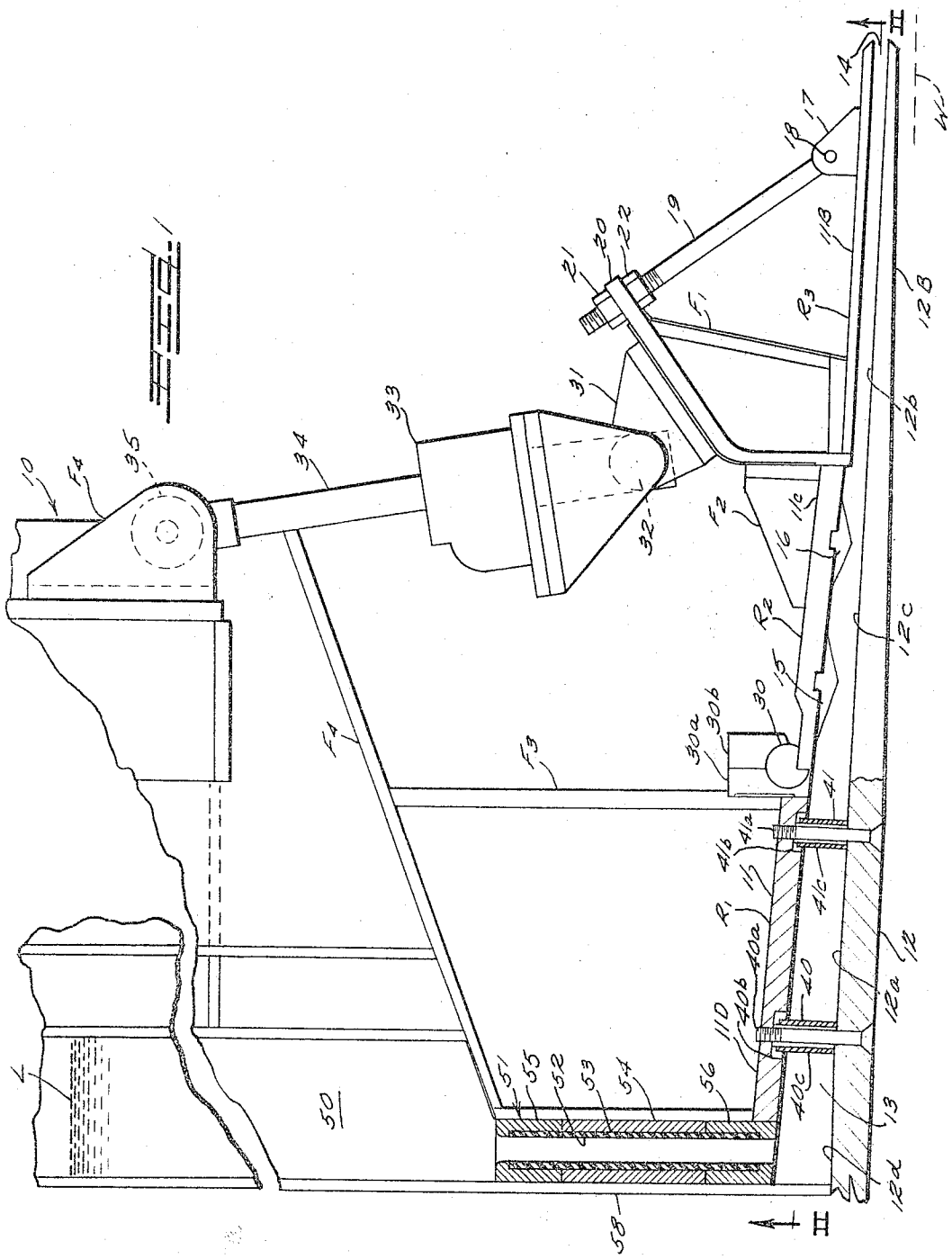
March 14, 1967 J. D. PARKER ETAL 3,309,264

FLOW DISTRIBUTOR FOR A PAPERMAKING MACHINE

Filed Jan. 17, 1964 4 Sheets-Sheet 1



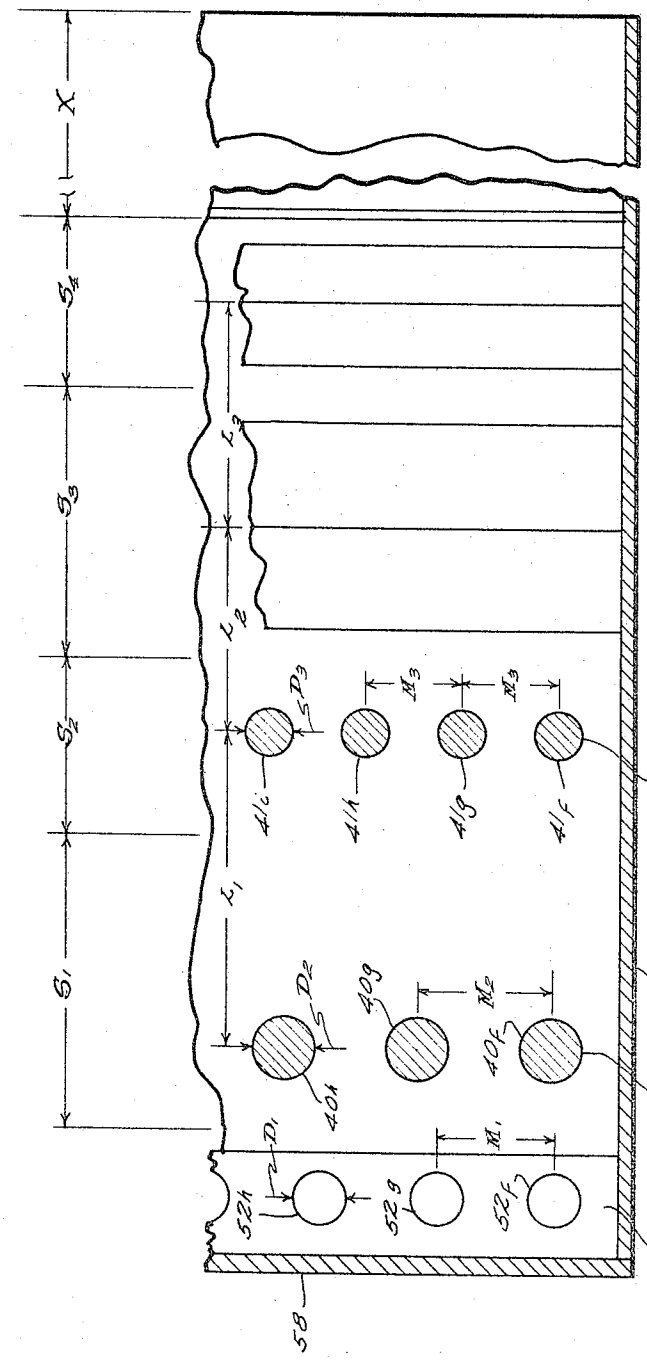
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March 14, 1967 J. D. PARKER ETAL 3,309,264

FLOW DISTRIBUTOR FOR A PAPERMAKING MACHINE

Filed Jan. 17, 1964 4 Sheets-Sheet 2



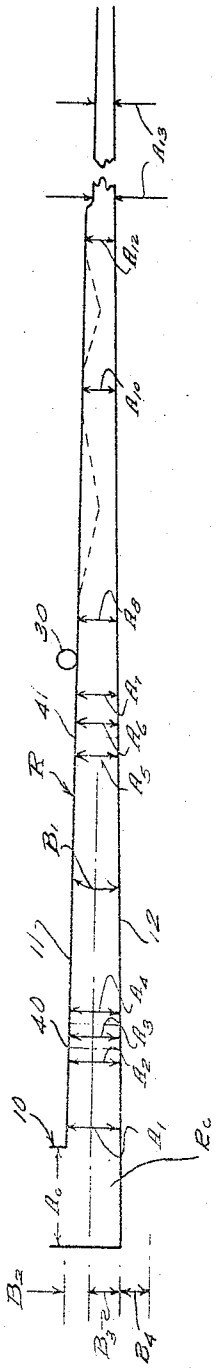

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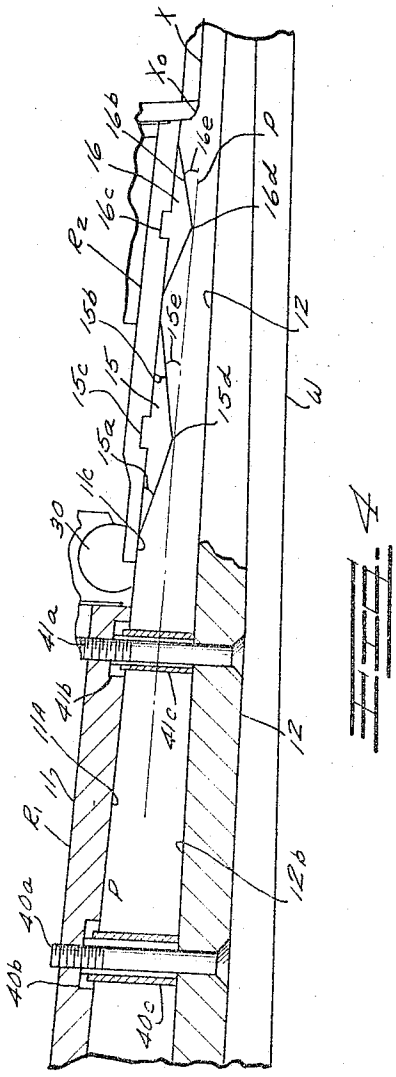
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FLOW DISTRIBUTOR FOR A PAPERMAKING MACHINE

Filed Jan. 17, 1964 4 Sheets-Sheet 3





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March 14, 1967 J. D. PARKER ETAL 3,309,264

FLOW DISTRIBUTOR FOR A PAPERMAKING MACHINE

Filed Jan. 17, 1964 4 Sheets-Sheet 4

FIG. 5

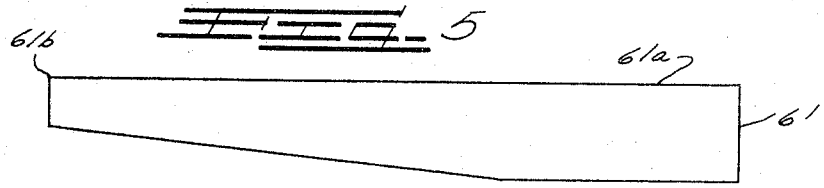



FIG. 6

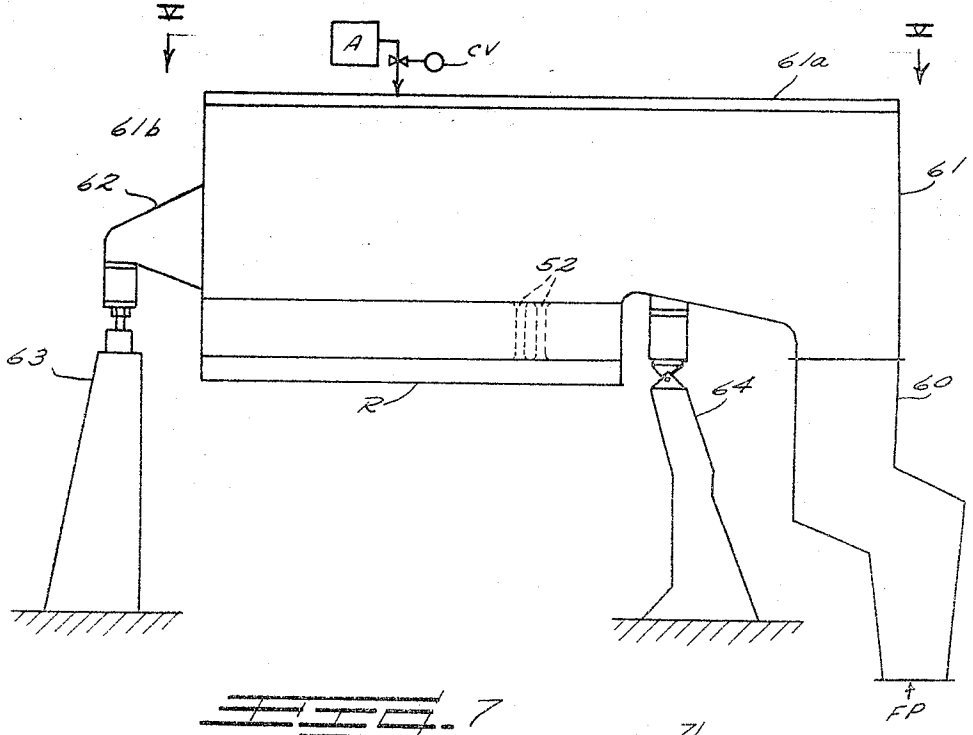
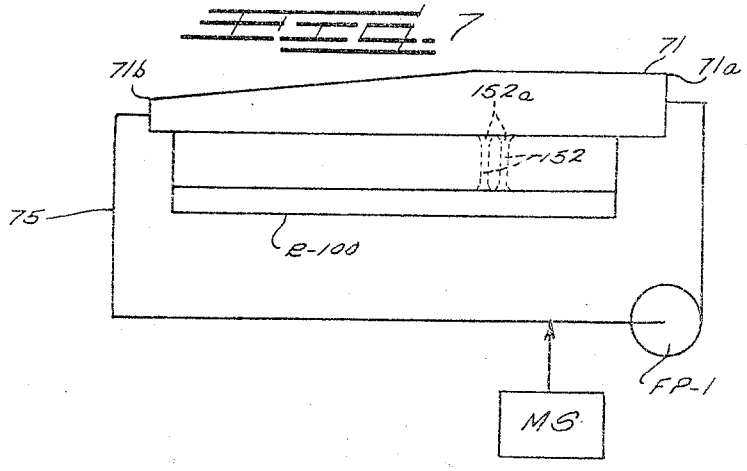



FIG. 7




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3,309,264

# FLOW DISTRIBUTOR FOR A PAPERMAKING MACHINE

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19 Claims. (Cl. 162—336)

Attention is directed to copending Parker and Schmaeng application Ser. No. 228,621, filed October 25, 1962, now Patent No. 3,220,919 and copending Parker and Jones applications Ser. Nos. 69,337 and 69,338, filed November 15, 1960, both now abandoned, disclosing in considerable detail various aspects of stock inlet construction referred to herein, and incorporated herein by reference.

This invention relates to the handling of fluid slurries, and more particularly, to the maintenance of desirable fiber distribution in stock slurries for paper making and the like processes.

Prior attempts to establish uniform distribution of fibers in the stock slurry and to maintain fiber distribution, once established, along the flow path or stream in the headbox prior to deposition of the stock on the traveling forming surface have involved employment of complicated auxiliary equipment such as perforated rotary rolls, commonly referred to as rectifier rolls, holey rolls or silencing rolls, and other mechanical vibrating, shaking and/or stirring devices, all of which do induce turbulent flow currents of large amplitude in the slurry and may well be useful in certain speeds for paper machine operation.

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

In essence, the difficulties of constructing a stock inlet for a paper machine are fundamental. The stock is a slurry consisting mostly of water and containing very small but significant amounts of fiber. The amounts may range from as little as about ¼ of 1% to as much as 1 or 5% perhaps in certain devices, but the basic difficulty involves not only the initial formulation of the stock slurry which is a process requiring the mixing of various so-called "furnishes" in the desired formulations but also the dilution thereof into a rapidly flowing stream, but the initial difficulties of mixing are not as such a part of the problem solved by the instant invention. A subsequent step in paper formation involves the transportation of the initially formed slurry or "stock" as it is referred to in the trade through adequate conduits to the inlet. These conduits are generally round in cross-sectional area or at least relatively compact in structure, so they deliver a stream of stock having substantial speed and volume but which is in such a condition that it could not possibly be used to form paper on a forming wire. The forming wire is a rapidly moving fine mesh looped screen which travels over appropriate rolls supporting a span of the same and which has a substantial width of perhaps 150 up to 340 or 350 inches. The stock must be flowed onto the forming wire at approximately the speed of the forming wire in linear velocity and in a distributed manner such that approximately the same quantity of fibers in the stock will be distributed to each cross-machine width of forming wire. This is, of course, not possible if the stock were to be passed onto the forming wire from a generally round stock flow conduit from the main pumping device, such as the so-called "fan pump," which delivers stock at a very high speed usually into a conduit of circular



cross-sectional area. The total volume of stock delivered by the fan pump per unit of time is usually more than the total volume of stock that is delivered to the forming wire in the same unit of time, so that recirculation and losses in flow and similar considerations may be taken into account in delivering the stock to the inlet. The inlet is the device which converts the stock flow from the fan pump into what is generally considered in the art as the so-called "slice" flow or jet.

At the inlet slice, one will find an opening that is substantially coextensive with the width of the forming wire (i.e. some 150 to 350 inches in cross-machine dimension), but which is ordinarily very small in the thickness or vertical height of the slice opening, so that the slice will deliver a stream of stock onto the top surface of the forming wire at approximately the speed or linear velocity of the forming wire, but in the form of a very thin stream (speaking in terms of the dimension of the stream perpendicular to the surface of the forming wire)

In present day paper machines, for example, very high speeds are desired and are achieved and as a typical example a speed of 2,400 feet per minute may be used, this is 40 feet per second, and the slice jet or stream must thus flow a thin ribbon-like stream of stock onto the top of the forming wire at a linear velocity of substantially 40 feet per second, which is a relatively high speed. At higher paper machine speeds of perhaps 3,000 feet per minute, the slice jet speed would be in the neighborhood of 50 feet per second; and at lower paper machine speeds the stock stream speed at the slice would be correspondingly lower. In addition, the total thickness of the web ultimately desired is a consideration in determining the thickness of the stock stream fed onto the forming wire. Thus, if a very thin paper sheet is ultimately desired, the slice outlet may well be very thin in dimension itself, in the neighborhood of perhaps ¼ inch, but in cases where a thicker paper sheet is desired or a paper sheet having greater weight per unit area, slice outlet openings of greater thicknesses in the neighborhood of perhaps as much as 1 inch are employed.

In contrast, the fan pump will ordinarily deliver the required volume of stock (plus the necessary excess for losses and recirculation) into a large generally circular header having a diameter of perhaps 1 to 3 feet, depending upon the particular type of paper machine involved, and the speed in this header will necessarily be correlated with the total volume discharge at the slice and the speed of discharge at the slice. The difficulty involved is that of constructing an inlet which will convert this rather compact relatively narrow but very thick (i.e. generally circular) stream of stock to a very thin wide stream of stock for use on the forming wire, while also obtaining the desired essential random distribution of fibers in this dilute stock slurry such that a felted type of fiber formation will occur in the web on the forming wire.

It is also recognized that even in the extremely dilute fibrous slurries of paper machine stocks, the water does not function in strict accordance with the principles of fluid flow of an ideal liquid, or even in accordance with the principles of flow of pure water. The distinctions are significant and students of this art have been studying the same for years and years. Moreover, the fibers themselves tend to recollect or flock at one time or another during the flow from the fan pump to the slice outlet and it is important to cause either a redistribution or to maintain a desired distribution of fibers in this slurry to such an extent that the desired felting of the fibers will take place after the high speed stock stream has been passed over the top of the forming wire and water from the stock starts to flow through the forming wire screen to deposit the fibers thereon in the course of paper formation. This redistribution of fibers and/or maintenance

of fiber distribution is as important a part of the inlet construction as is the actual redistribution of the flow from the generally circular stock stream at the exit of a fan pump to the extremely thin and wide stock stream at the slice outlet. The control of uniformity flow has resulted in numerous studies which need not be described in great detail.

In addition, the general condition of the prior art with relation to inlets of the type with which we are presently concerned is shown in the references of record in the aforesaid applications. It will be noted that in some of these references the patentees have resorted to a great multiplicity of pipes which are used to continuously split the stock stream into ever-decreasing stream sizes and in others the stock stream is fed into large vats or tanks which are intended to afford an opportunity to convert the rapidly flowing fan pump discharge into what was believed at the time by the patentee to be a suitable distribution of fibers at a somewhat slower speed in the stock. The instant invention relates to an improvement over all of these devices.

It is, therefore, an important object of the instant invention to provide an improved method and apparatus for effecting the desired distribution of particulate material in a liquid vehicle, such as fibers in paper making stock or slurry and the desired conversion of such stock stream from a generally thick high speed stream to an extremely wide and thin slice discharge stock stream.

Other objects, features and advantages of the present invention will become apparent to those skilled in the art from the following detailed disclosure thereof and the drawings attached hereto and made a part hereof.

On the drawings:

FIGURE 1 is an elevational view, with parts broken away and parts shown in section of an inlet or headbox for use in the practice of the invention;

FIGURE 2 is an essentially diagrammatic fragmentary cross-machine section, with parts broken away and parts shown in section, taken generally along the line of the roof of the inlet of FIGURE 1, such line being indicated at II—II;

FIGURE 3 is an essentially schematic view shown in elevation to correspond to the elevational view of the inlet indicated in FIGURE 1, but again with certain parts broken away, and the view of FIGURE 3 is intended to represent generally the variations in cross-sectional area of the controlled thin portions of the stock inlet;

FIGURE 4 is a fragmentary detail enlarged view of certain essential elements in the central portion of the narrow stock inlet of FIGURE 1, taken approximately from the same view as that shown in FIGURE 1, but showing these essential elements in enlarged elevation and section;

FIGURE 5 is an essentially diagrammatic top plan view of a cross-flow header for stock for the inlet of the embodiment of the instant invention;

FIGURE 6 is an essentially diagrammatic elevational view showing the overall inlet assembly of the instant invention taken generally from the rear side of the inlet; and

FIGURE 7 is an essentially diagrammatic view comparable to that of FIGURE 6 but showing still another embodiment of the instant invention.

As shown on the drawings:

In FIGURE 1 there is shown the essential concept of the inlet of the invention from a side elevational view with parts shown in section, showing primarily certain fundamental features of the instant inlet designated generally by the reference numeral **10**. These include generally closely spaced, laterally or cross-machine extending top **11** and bottom **12** walls which converge from a relatively thin (i.e. small in height) inlet **13**, from which the walls **11** and **12** extend longitudinally from right to left in the direction of stock flow in the device **10** a substantial distance convergingly, in fact, so as to converge approximately at an angle of convergence of about 3°, but which may range from a minimum practical angle of convergence of about 1° to a maximum practical angle of convergence of about 10°, which angle of convergence is indicated in the schematic showing or FIGURE 3 as the angle $B_1$, or as the total of the two halves indicated at $B_2$ and $B_3$ in FIGURE 3. In general, the top and bottom walls **11** and **12** extend the full width of the paper machine which may range from minimum commercial machine sizes in the neighborhood of 100 to 150 inches to as much as the maximum known commercial machine sizes which are now in the neighborhood of about 340 or 350 inches. In contrast, the longitudinal dimension of these walls **11** and **12** in the direction of stock flow from the inlet **13** to the very small outlet indicated at **14** in FIGURE 1, which outlet is referred to in paper making as the slice, will ordinarily be only about 40 to 50 inches, or something in the neighborhood of ⅓ to $\frac{1}{10}$ of the cross-machine dimension for the walls **11** and **12**.



As the terms are used herein, transverse refers to the cross-machine direction whereas longitudinal refers to the so-called machine direction. The stock flows through the inlet portion defined between the generally converging walls **11** and **12** in a generally longitudinal direction toward the slice **14**, from which it flows (usually through a slight drop) onto a traveling forming surface which is usually the very fine woven screen that is referred to in the paper machine trade as the forming wire. The stock may thus be fed from the slice **14** onto the top of one forming wire or between two converging forming wires, depending upon the type of forming device to be used. In the instant invention, we are concerned primarily with the inlet itself and the conversion of the stock flow from the initial generally transverse or cross-machine introductory stock flow to an essentially longitudinal thin stream of stock flowing through the slice **14**. The stock velocity at the slice **14** is essentially the velocity of the forming wire W and thus, as previously indicated, in a paper machine operating at 2,400 feet per minute the linear velocity of stock at the slice **14** will be approximately 40 feet per second. The slice **14** has a definite but very thin dimension as well as its very substantial transverse dimension. This thin dimension is generally perpendicular to the horizontal or to the forming wire itself, with respect to the alignment of the dimension, which is indicated schematically in FIGURE 3 as the dimension $A_{13}$.

The dimension $A_{13}$ is in effect the cross-sectional area (or at least representative of the cross-sectional area) of the slice **14** from which the stock onto the forming wire at a linear velocity of, for example, 40 feet per second. It will be appreciated that if we are to assume negligible frictional losses, then we may assume that the stock linear velocity at any point in this inlet between the walls **11** and **12** will be approximately inversely proportional to the ratio between the cross-sectional area at the location in question and the cross-sectional area of the slice itself. Thus, referring to FIGURE 3, we see that the cross-sectional area of the slice is represented by the dimension $A_{13}$ whereas the cross-sectional area of the inlet previously described in connection with FIGURE 1 as **13** is designated in FIGURE 3 by the reference letter $A_1$. Assuming the back pressures on the stock flowing the full longitudinal dimension of this portion of the inlet, which is generally considered to be the inlet channel R, is substantially constant at all times, it can be assumed that the velocity of the stock in the londitudinal direction of flow in the region of the inlet $A_1$ will be 40 times $A_{13}$ divided by $A_1$. In other words, if the slice velocity is 40 feet per second at a cross-sectional area of $A_{13}$, then the stock velocity coming into the channel R in the region $A_1$ would be only 20 feet per second if the dimension $A_1$ is twice the dimension $A_{13}$, which happens to be approximately the case, although in the preferred embodiment

of the instant invention the dimension $A_1$ is actually closer to about three times the dimension $A_{13}$.

In any event, it is apparent from the showing in FIGURE 1 and the schematic showing in FIGURE 3 that the top wall or roof **11** and the bottom wall or floor **12** converge gradually and thus they impart to the stock a continuously increasing velocity over the longitudinal dimension of the inlet channel R. It will also be noted that the surface **12***a* of the floor or bottom wall **12** is a relatively smooth straight surface that slopes downwardly slightly toward the forming wire W and the angle of slope is indicated at $B_4$ schematically in FIGURE 3 with reference to the wire line WL, and it will be noted that this angle of slope $B_4$ is preferably in the neighborhood of about ½ to 5 or even 10 degrees depending upon the type of inlet desired. In general, the purpose of the inlet is to feed the stock through the slice **14** in generally substantially parallel alignment with respect to the forming wire so the floor **12***a* should have only a very slight downward slope in the neighborhood of about 1 to 3° from the horizontal, and preferably about 2° as here shown in order to permit stock flow out of the inlet during shutdown and avoid the collection of pools of stock on the surface of the floor **12***a* during such shutdown of the device. Added to this convenience is the fact that the bump-like turbulence generators indicated in FIGURE 1 generally at **15** and **16** in the intermediate section $R_2$ of the channel are mounted only on the roof of the channel. The forward section of the channel $R_3$ is defined between two relatively narrow wall sections of the roof **11B** and the floor **12B** which provide a channel spacing indicated schematically in FIGURE 3 as $A_{13}$ that is substantially equal for the full dimension of this exit or terminal section $R_3$ of the channel. As is indicated in FIGURE 1, the roof portion **11B** is secured rather rigidly by suitable means such as welds or bolts (not shown) to the roof section **11C** of the second section $R_2$ of the channel, by framing generally indicated at $F_1$ and $F_2$, such framing $F_1$ and $F_2$ extending the full width of the machine and being connected by bolts or welds (not shown) in such a manner as to afford a generally rigid connection betwen the intermediate roof section **11C** and the exit roof section **11B**, leaving the exit roof section **11B** to extend in a generally cantilever type mounting longitudinally to the slice **14**. It will be noted, however, that the slice extremity of the roof portion **11B** is provided with a plurality of ears, only one of which is shown at **17**, each having pivotal connections **18** to rods **19** that are adjustably connected to a flange portion **20** on the framing $F_1$ via twin lock nuts **21** and **22** which afford limited adjustment of the rod **19** longitudinally or axially so as to afford limited local adjustment of the relative spacing between the slice extremity of the roof wall portion **11B** and the channel floor portion opposite thereto designated **12B**. This is for very minor adjustment of flow via very minor adjustment of the cross-sectional area in the local region, since the overall cross-sectional area in the final exit section $R_3$ of the inlet shown in FIGURE 1 is generally uniform and is designated schematically in FIGURE 3 as being generally of the dimension $A_{13}$ throughout its entire transverse as well as longitudinal dimension.

The essential convergence of the walls **11** and **12** thus takes place at the first channel section $R_1$ and the second channel section $R_2$, which are already indicated as converging approximately along an angle of convergence $B_1$ of about 3 to 5°, and preferably about 3°. In addition to the limited adjustment for the final roof portion **11B** via the rods **19**, it will be appreciated that the final roof portion **11B** securely anchored to the intermediate roof portion **11C** is carried by a cross-machine pivot, indicated generally at **30** in FIGURE 1. The pivot **30** is carried in mating blocks **30***a* and **30***b* carried on the forward end of a generally rigid cross-machine frame element $F_3$ which also carries the forward end of the roof portion **11D** of the first channel section $R_1$. The connected cross-machine framing sections $F_1$ and $F_2$ also have an ear **31** carrying a pivot **32** at opposite sides of the machine (only one of which being shown in FIGURE 1) which pivots **32** are connected through motors shown schematically at **33** to the tie rods **34** which are in turn mounted on the fixed framing $F_4$ by pivots **35**. The motor **33** is of conventional structure and is used to coact with the tie rods **34** to lift the forward roof wall portions **11C** and **11B** simultaneously in and out of operating position and to leave open a corresponding flat smooth merging sequence of wall surfaces **12***c* and **12***b* which form the continuation of the floor **12***a* for the bottom of the channel R from the inlet **13** down to the slice **14** at the gradual slope of approximately 2° hereinbefore mentioned. It will thus be seen that the swinging of the roof portions **11C** and **11B** out of operating position will leave exposed an open smooth flat floor area **12***c*–**12***b* which will not collect pools of stock and which can be readily worked on to the extent required and will be readily exposed as a clean smooth surface for this purpose. In this way the turbulence generators **15** and **16** which will be described in detail hereinafter are moved out of operating position also and, by carrying these turbulence generators **15** and **16** on the roof portion **11C** which is swingable in and out of operating position, it is possible to make available a flat floor section **12***c*–**12***b* available for immediate maintenance in the most convenient manner.

In contrast, in connection with the first channel portion or section $R_1$, it will be seen that turbulence generators are indicated generally at **40** and **41** in the form of transversely extending rod banks, which will be described in greater detail hereinafter, but which will be understood to be defined by a multiplicity of relative small abutments extending between the walls **11** and **12** to afford support thereto and also to afford controlled reduction in the cross-sectional area in the immediate location thereof and further, it being generally rods, terminating abruptly at the downstream end thereof for desired vortex turbulence generation in the stock flowing past such rods. The upstream sides of the rods are smooth and rounded so as not to collect fibers or strings thereon. This in the general structure of the rods in the banks **40** and **41**, which will be discussed in greater detail hereinafter, but which for the moment will be described directly in connection with the overall support of the physical structure in that these rods **40** and **41** actually maintain the top and bottom walls **11** and **12** in the desired converging closely spaced relation hereinbefore described. Above this initial section $R_1$, it will be seen in FIGURE 1 that there is provided substantial reinforcement and additional framing including the upright framing $F_3$ and additional framing $F_4$ thereabove which mounts the pivots **35** hereinbefore described and which also mounts the initial stock inlet indicated generally at **50** at the left end of FIGURE 1 and showing in the fragmentary view a definite level L also at the left hand side of FIGURE 1.

The particular details of the framing $F_4$ do not require additional description, since the general nature of cross-machine framing and mounting of pivots such as the pivots **35** will be fully understood by those skilled in the art. The cross-machine or transversely flowing stock **50** at the level L is indicated as the stock which enters the inlet **10** initially from one side of the machine and then flows downwardly through a perforated body indicated generally at **51** which actually constitutes a multiplicity of transversely spaced tubes only one of which **52** is shown in FIGURE 1. These tubes are shown as being provided with a suitable noncorrosive cylindrical liner **53** which is preferably synthetic rubber or some other noncorrosive material that is mounted in cylindrical stainless steel spacers or backers **54** which are mounted in alignment with perforations in a top cross-beam **55** and a bottom cross-beam **56** to complete the extension of the tubular

conduits **52**, each of which have a substantial length-to-diameter ratio of at least 7:1 and preferably in the neighborhood of 10 to 15:1 or more, depending upon the space available for the mounting of these tubes **52**. Again, it wil be appreciated that the essential concept of fiber distribution within the individual tubes **52** by virtue of high velocity stock flow vertically downwardly therethrough is accomplished preferably by the use of the length-to-diameter ratios specified. It will be appreciated that essentially there must be a stock jet generation in this area in the form of a myriad or multiplicity of generally transversely aligned (and spaced) individual stock jets each of which will lie in a separate (usually) plane that is longitudinally aligned with respect to the overall inlet. Thus the plane of the section shown in FIGURE 1 is longitudinally aligned and so will the planes be aligned which are parallel thereto and which pass through the respective axes of the successive transversely spaced tubes in the transverse series thereof. In general, the alignment of stock in the jet streams within the tubes **52** is the first step in converting the stock from the transverse flow in the inlet **50** to flow in a longitudinal direction, even though the stock flows directly out of the tubes **52** and against the channel floor at **12***d* to impinge thereon and develop lateral stock flow components as well as additional longitudinal stock flow components in the direction of the channel inlet **13**. The impingement of stock against the floor **12***d* which functions as a baffle results in a general change in direction of stock flow of at least about 90° (in this case substantially 90°) which effects by virtue of such impingement and turning of the stock streams the required reconversion of lateral flow components in the stock so that the stock is spread laterally in such a manner that it will tend to enter the channel inlet **13** at approximately the same or at least a substantially uniform transverse pressure profile and overall stock linear velocity. It will be appreciated that the effects of impingement against the wall **12***d* and the immediate spreading of the stock in this chamber area will cause a rapid decleration of stock flow from the point of view of linear velocity and will result in what might be considered heterogeneous rather than uniform stock flow components, but at the same time it will result in a spreading of the stock in such a manner, under the particular conditions here involved, that the overall stock pressure entering the very thin inlet end **13** of the channel R will be generally uniform and at this stage we will have approximated a conversion from an essentially transverse or cross-machine stock flow to an essentially and generally uniform longitudinal stock flow in a thin stream at the inlet **13**.

Before going into further detail in connection with the nature of the turbulence generators hereinbefore noted in the succession **40**, **41**, **15** and **16**, reference is made to the overall cross-machine stock flow inlet devices in FIGURES 5, 6 and 7.

Referring first to FIGURE 6, it will be seen that the stock flows from a fan pump FP, indicated only as an arrow for schematic purposes, upwardly through a vertical channel **60** and into a cross-machine channel **61**. It will be noted that the general profile shown in FIGURE 5 is really a top plan of FIGURE 6 of the channel **61** showing an enlarged inlet end **61***a* and a relatively narrow opposite end **61***b*. The channel **61** thus extends in a cross-machine direction but it diminishes in cross-sectional area in the cross-machine direction.

As indicated in FIGURE 6, the overall cross-machine channel **61** need not be built for stock recirculation therethrough and can simply be mounted on a structural arm **62** extending outwardly from the narrow end **61***b* and mounted on a conventional supporting pillar **63**, while the inlet end **61***a* is also mounted on a corresponding supporting pillar **64** in corresponding manner so that the cross-machine channel **61** will be maintained generally horizontal. It will also be noted that a source of gas such as air A under pressure is shown diagrammatically being fed through a control valve CV into the top of the cross-machine channel **61** so as to maintain a predetermined superatmospheric pressure on top of the level (L of FIGURE 1) of the stock in the cross-machine channel **61**. The combination of the taper or diminution in cross-sectional area in the channel **51** and the superatmospheric air pressure maintained on the top thereof will have the effect of presenting stock to the top of each of the small perforations or mouths for the tubes (only two of which are indicated at **52**, **52** and dotted lines in FIGURE 6) so that a generally uniform cross-machine pressure is exerted against the stock at the mouth or tops of each of the tubes **52** and the stock jet or stream generated therein will thus be substantially uniform in velocity, volume, turbulence and other characteristics. These tubes **52**, **52** will then feed the stock into the channel R which is shown only from the rear in FIGURE 6 and then schematically in order to avoid confusing the view.

In an alternative embodiment also shown schematically, in FIGURE 7, it will be seen that a fan pump **FP–1** feeds stock into the inlet side **71***a* of a generally cylindrical tapered header **71** extending in cross-machine direction toward a relatively narrow exit end **71***b*, from which a certain amount of stock is recirculated through the conduit indicated at **75** back into the inlet of the fan pump FP–1 and makeup stock MS is also fed into the inlet of the fan pump FP–1 to maintain the desired amount of total stock entering the tapered cross-machine header **71**. The tapered cross-machine header **71** will thus provide by means of pressure control from the fan pump FP–1 and the effect of the gradually diminishing cross-sectional area of the body of the header **71** itself a generally transversely uniform inlet pressure into the mouths **152***a*, **152***a* of the multiplicity of transversely spaced tubes, only two of which are indicated schematically at **152**, **152** in FIGURE 7, so that the stock will flow in jets downwardly into the channel inlet indicated in FIGURE 7 as R–**100** corresponding to the channel R of FIGURE 6.

Referring now generally to the overall stock velocities in the inlet **10** shown schematically in FIGURE 3, it will be appreciated that reference must be had first to what may be considered to be the controlling velocity and that will be the velocity of the stock in the slice channel $A_{13}$, which is approximately the linear velocity of the forming wire itself. Previously we have assumed a paper machine speed of 2,400 feet per minute which will mean a stock velocity at the slice $A_{13}$ of 40 feet per minute. This will not necessarily determine the exact size or thickness of the slice $A_{13}$ here indicated schematically, because for certain weights of paper a greater total volume of stock will be employed than in other cases. The linear velocity will be the same or substantially the same for each paper machine speed, but the slice opening $A_{13}$ will differ with different weights of stock.

If we are to assume in terms of sixteenths of an inch that the thickness of the slice $A_{13}$ in this particular instance is substantially $1\frac{2}{16}$ of an inch then the cross-sectional area indicated by the number **12** represents a number of units which correspond in cross-sectional area to a linear velocity of 40 feet per second. Using **12** as a reference, it will be seen that the open area $A_0$ in the region of the stock jets or tubes (hereinbefore described at **52**) is comparatively limited and a high velocity high pressure stock jet is desired in this area. Accordingly, the linear velocity in the tubes **52**, expressed in terms of the overall open area $A_0$ will preferably range from about the slice speed to twice the slice speed, or expressed in the numerical terminology, the area ratios $A_0$:$A_{13}$ will range from 1:1 to 2:1 and are preferably about 12:7. This results in a very high stock velocity for impingement against the floor extension **12***d* and for turning the stock jets through substantially at least about 90°. As previously mentioned, the best overall control of the stock

jets is obtained by using a length-to-diameter ratio within the tubes **52** of at least about 7:1 and preferably 10 to 15:1 and actually up to about 25 or 30:1, depending to a great extent upon the limitations of available space. In any event, better results are obtained using ratios of at least about 7:1 such that uniformity of stock flow in the individual jets is obtained and the various other desirable characteristics in stock flow are obtained and maintained with greater facility. The impingement of these jets is preferably carried out against the floor **12***d* of the overall channel section R for the reason that this simplifies the structure and the stock then immediately impinges upon the first set of turbulence generators **40**.

As indicated in FIGURE 1, the individual turbulence generators **40** and **41** in the two banks are actually formed by through bolts **40***a* and **41***a* extending through the floor **12** and in threaded engagement in the roof **11** seating in appropriate roof recesses annular locking devices **40***b* and **41***b* in the roof **11** (which are shown in full view for purposes of simplifying the drawing) which provide the necessary annular recess to receive the top of the rod covers **40***c* and **41***c* which in each case is preferably a noncorrosive material such as a solid elastomer (i.e. synthetic rubber or a stainless steel material) in the form of a tube which slopes over the tie rods **40***a* and **41***a* and is mounted in the annular seating devices **40***b* and **41***b* so as to remain rigid and in clamped position during operation. The details of the individual rods **40** and **41** are directed essentially to the problems of convenient mounting and in the schematic view of FIGURE 2, these details are not shown. FIGURE 2 is concerned primarily with the concepts of turbulence generation. It will be seen from FIGURE 2 that, looking upwardly toward the roof as the view II—II of FIGURE 1 indicates, one will note the discharges of the transversely spaced tubes indicated at **52***f*, **52***g* and **52***h* in the bottom perforate plate hereinbefore described by the reference numeral **56**. Side channel walls are, of course, provided, although only the single wall **57** is shown and the end wall **58** is of course provided and is actually reinforced in the structure of the instant device to hold the pressure. The tubes **52** are indicated as having diameters $D_1$ which are spaced on centers $M_1$ such that the overall open area is $A_0$, which is described hereinbefore as being preferably an open area $A_0$ equalling in total to from 50% to about 100% of the slice cross-sectional area $A_{13}$. In essence, the tubes **52** should have relatively small diameters in the neighborhood of about 1 inch and should be approximately 12 inches in length so as to effect the desired stock jet generation and this will result in their centers being approximately 2 inches apart in the spacing $M_1$ herein indicated for the diameters $D_1$ in FIGURE 2. The spacing arrangement can be changed and the open area can be changed therein such that the diameters $D_1$ may range from ½ to 1½ inches and the spacing between the centers thereof may range from slightly more than $D_1$ to as much as two or three times $D_1$. The smaller the overall open area $A_0$ in this region, the greater the jet velocity impinging against the floor **12***d*. The stock impinges against the floor **12***d* as indicated in FIGURE 1, and then makes the right angle turn. In making the right angle turn after impingement upon the floor **12***d*, it will be appreciated that the stock flows into a chamber area having a substantially greater cross-sectional area $A_1$ which numerically speaking affords a cross-sectional area ratio $A_0$:$A_1$ ranging from about 7:20 to 60, and is preferably about 7:40, which affords a deceleration of stock velocity that averages such that the stock velocity is reduced from the jet velocity to about ⅕ to ⅙ of the jet velocity in the initial impingement, deceleration and turning chamber indicated schematically at $R_3$ in FIGURE 3. The stock then proceeds into the inlet indicated diagrammatically at $A_1$ in such a manner as to have imposed on the stock a primary velocity increase in the direction of the slice $A_{13}$ by virtue of the converging walls.

The walls **11** and **12** preferably converge along a general angle of convergence of about 3 to 5°, but under certain conditions this range may be expanded to from 1 to 10°. It must be appreciated that a pair of closely spaced walls **11** and **12** in the total absence of any turbulence generating devices **40**, **41**, **15**, **16**, etc. may extend for a very substantial longitudinal dimension (much greater than the approximately 4 or 5 feet here shown) so as to impart to the stock a generally uniform cross-machine velocity profile as well as imparting the desired turbulence within the stock itself. By cross-machine velocity profile, we refer to the longitudinal speed of stock at various cross-machine locations in a given region such as along a plane taken through the line $A_1$ in FIGURE 3. It is desirable to develop a generally uniform longitudinal velocity component in the stock across the full width of the machine. It must be appreciated that initially the stock flowing in the cross-machine header **61** has no longitudinal velocity component at all. Even in the jet streams in the tubes **52**, the forward longitudinal component is 0, although the stock streams have been converted from a cross-machine direction to at least parallel planes in longitudinal alignment. This is followed by impingement and then a series of turbulence generating devices **41**, **41**, **15**, **16**, etc. or expressed in other words, a plurality of sequences wherein the stock will go rapidly through comparatively maximum and minimum cross-sectional areas (from the transverse cross-sectional area point of view) so as to superimpose upon the overall generally increasing primary velocity a distinct and rather drastic secondary velocity change in the stock. This distinct secondary velocity change in each of these so-called sequences $S_1$, $S_2$, $S_3$, $S_4$ indicated in FIGURE 2 will in each case effect a certain amount of correction of the overall cross-machine velocity profile.

For convenient reference in the claims hereof, the longitudinal dimension of each such sequence may be defined as extending from a maximum to and through the adjacent minimum and to the next maximum of such cross sectional areas, e.g., in FIGURES 2 and 3, from about $A_8$ through **15** to about $A_{10}$ for $S_3$, or from about $A_{4.5}$ (FIGURE 2) or $A_5$ (FIGURE 3) to and through **41** to about $A_7$ or $A_8$ for $S_2$. Since the concept of a sequence herein is a "cycle" in secondary velocity changes, the actual longitudinal dimensions for $S_2$ and $S_3$, for example, compare in theory essentially to the cyclic concept indicated at $L_2$ (FIGURE 2) representing the dimension of a cycle from a maximum **41** to and through the adjacent minimum $A_7$, $A_8$ and to the next maximum **15** secondary velocity regions. The turbulence generators are at the ends of the cycle $L_2$, but in the middle of $S_2$ or $S_3$, hence the latter definition is generally a more convenient mode of expressing and/or defining the sequence and their relative positional and functional relationships.

In the sequences herein described, it is preferable that at least the first two sequences $S_1$ and $S_2$ be defined by abutments which terminate abruptly at the downstream side so as to effect vortex turbulence generation and so as to effect relatively drastic turbulence generation, compared to that generated later on. Preferably this is done using a multiplicity of rod banks, in which banks each rod **40***f*, **40***g*, **40***h*, etc. will be generally cylindrical in form and in the case of the first sequence $S_1$, will have approximately a diameter $D_2$ of about 1½ inches. The center spacing therebetween is preferably about twice the diameter hence $M_2$ is preferably 2 times $D_2$ in order to provide an open area of approximately 50% and thus obtain the desired turbulene. As a matter of fact the open area may range from perhaps about 25% to 75%, but 50% has been found to be preferable and the particular center-to-center space $M_2$ is also found to be significant in that the individual rods or abutments in the first bank **40** will leave trailing wakes and this is desirable. The rods in the initial bank **40** are of substantial size and are smoothly curved at their upstream ends so that they

will not collect fibers, strings, or other matter and they will remain clean. This is very important from the point of view of continuous operation of the device. In addition, they will generate turbulence (sometimes referred to as vortex-type turbulence) as the downstream side thereof because they terminate abruptly at the downstream sides of each of such rods (by virtue of their circular cross-section) and this turbulence will start to decay at the off-running side of the first rod bank 40, but it will not have completely decayed within a dimension $L_1$ which is preferably within the range of about two to five times $M_2$. The preferred relationship between the center-to-center spacing of the rods or abutments in one bank and the downstream spacing of the rods or abutments 41 in the second bank (i.e. the distance $L_1$) is described in considerable detail in the previously mentioned application Ser. No. 228,621 and need not be described in further detail herein. Essentially, the function involves that of having turbulence in a condition of partial but incomplete decay as the stock impinges upon the relatively smaller smooth round upstream surfaces of the rod bank 41, as indicated in connection with the individual rods 41*f*, 41*g*, 41*h*, 41*i*, etc. The individual rods 41 are about 1 inch in diameter which is approximately a preferred size so that the relationship between the diameters $D_2$:$D_3$ will be about 1:0.9 to 0.5 and preferably about 3:2. The upstream rods 40 are of comparatively large size so that it will be possible to make sure that there will be no collection of fibers or the like thereon. In addition, the upstream faces of these rods 40 will be continuously cleaned by the net effect of the impinging jets against the floor and the miscellaneous currents in the stock generated thereby. This is the type of turbulence generation of rather substantial scale which is effected at this stage in the inlet at the stage indicated diagrammatically at $A_1$ in FIGURE 3. As the stock approaches the oncoming side of the first bank of rods 40, it will be appreciated that the cross-sectional area of the channel R has diminished slightly to $A_2$, but this diminution is not particularly significant. In the middle of the rod bank 40 extending transversely of the machine, however, it must be appreciated that there is a drastic reduction in overall cross-sectional area $A_3$ and as here shown this is approximately a 50% reduction. The net result will be a velocity increase in the neighborhood of about 100% as the stock moves from the location $A_3$ at the oncoming side of the rod bank to the middle of the rod bank 40 at the location $A_3$; and then as the stock completes the sequence $S_1$ of the initial sequence herein desscribed, the stock exits from the initial rod bank 40 and reaches a substantially greater cross-sectional area $A_4$ indicated in FIGURE 3. It will be appreciated that the overall cross channel cross-sectional areas indicated by the units $A_1$:$A_2$:$A_4$ will in effect constitute decreases in the neighborhood of ratios of approximately 40:35 to 39:33 to 38, etc. so that there is a primary velocity increase, but there is a drastic reduction in cross-sectional area in the middle of the sequence $S_1$ at $A_3$, such that the open area of cross-sectional area ratio $A_2$:$A_3$ will range from 4:1 to 4:3 and is preferably about 2:1, with velocity changes in substantially the inverse ratio. On other words, with a velocity increase at the decreased cross-sectional area $A_3$.

In referring to the sequences $S_1$, $S_2$, etc. herein, it will be appreciated that each sequence is in effect a cycle through which the stock is put sequentially from a minimum to a maximum and then to a minimum or conversely from a maximum then to a minimum and back to a maximum cross-sectional area. As here described schematically, each sequence goes through the cycle from maximum to minimum to maximum cross-sectional area, and it will be appreciated that the second "maximum" cross-sectional area is slightly smaller than the first, in other words $A_4$ is a maximum that is slightly smaller than $A_2$ because of the general convergence of the walls and the general reduction in cross-sectional area of the channel which is undergone during the overall longitudinal movement of the stock through the channel.

It will also be appreciated that each sequence $S_1$, $S_2$, $S_3$, $S_4$, will have a general longitudinal dimension which is indicated schematically in FIGURE 2 in that it will involve the flow of stock approaching whatever the turbulence generating device might be plus the flow of stock past the turbulence generating device and then the flow of stock into what amounts to the subsequent maximum cross-sectional area, which for the sequence $S_1$ involves the sequence shown schematically in FIGURE 3 as $A_2$, $A_3$, $A_4$. The exact longitudinal dimension is not absolutely critical, but it may be considered to be a dimension from approxmiately midway between one set of turbulence generators to midway between the next set of turbulence generators, as in the case of the later sequences $S_2$, $S_3$, $S_4$.

The two rod banks 40 and 41 thus preferably have the same open areas and this is preferably approximately a 50% open area so that there is an effective doubling of the velocity at least in the secondary or superimposed stock velocity at each of the sequences $S_1$ and $S_2$ and the overall turbulence generation is such that the second rod bank 41 receives turbulence from the upstream rod bank 40 so as to keep the upstream faces of the rods 41 clean and permit the use of relatively smaller diameter $D_3$ rods in the bank.

Rather than having a multiplicity of smaller and smaller rods, which must necessarily in each case result in some trailing vortex tubulence generation because of the abrupt downstream termination of a rod by the very nature of the construction, the instant inlet provides still another type of turbulence generation in the latter sequences $S_3$ and $S_4$ (i.e. at least the last two sequences) before the exit X.

As has previously been described, the exit chamber X is preferably defined by a pair of smooth closely spaced walls that are generally equidistant and effect whatever turbulence generation they are capable of effecting purely by virtue of the fact that the stock stream flowing thereby is moving at a very rapid rate and the walls are necessarily standing still. This exit region X preferably has a longitudinal dimension that is at least as great as that of the last sequence $S_4$ and preferably at least as great as twice or more the longitudinal dimension of the last sequence $S_4$. In fact, in the arrangement here shown, the exit section X has a longitudinal dimension that is substantially three times that of the last sequence $S_4$. This results in turbulence decay. It is desired to obtain a certain amount of turbulence decay in the final exit chamber. Actually the amount of turbulence decay will depend upon the velocity of stock in the channel R. If the velocity is very slow, the turbulence generating devices will have to be more closely spaced and the exit chamber X will not be very long, because the benefit of turbulence generation and deflocking will not want to be lost completely. On the other hand, if the stock speed is relatively high even the closely spaced walls of the exit chamber X will impart a certain amount of turbulence and they will permit a great deal of equalizing or generation of uniformity in the fiber distribution if they are at least equal to two or three times the longitudinal dimension $S_4$ of the last sequence.

Referring to the sequences $S_3$ and $S_4$, it will be appreciated that these turbulence generating devices are shear generators. In other words, they do not rely solely on the vortex turbulence generation concept that necessarily results from the abrupt downstream ends of rods. Instead, they impart a general shearing effect to the stock stream.

Considering first the average velocity in the stock, it will be appreciated that as the stock moves from the position $A_1$ to the position $A_7$ in FIGURE 3 it has already gone through two sequences $S_1$ and $S_2$ in which in doubling of the stock velocity has been superimposed

upon the primary generally increasing stock velocity by virtue of the two reductions in cross-sectional area at the locations $A_3$ and $A_6$. The primary reduction in cross-sectional area from $A_1$ to $A_7$ and thus the corresponding primary increase in stock velocity from $A_1$ to $A_7$ is in an approximate ratio of 30:35 to 50. Preferably the ratio of $A_1$ to $A_7$ is about 4:3 and the velocity increase is thus the inverse of this cross-sectional area ratio by the end of the second sequence $S_2$. In the third and fourth sequences $S_3$ and $S_4$, the cross-sectional areas go through the ranges $A_8$ and $A_9$, $A_{10}$ in maximum minimum maximum such that $A_9$ is in a cross-sectional area ratio to $A_8$ within the range of about $A_8$:$A_9$ ranging from 4:1 to 4:3, but preferably about 2:1. This again results in an approximate superimposition of double the velocity in the region $A_9$ with almost a halving of the velocity in the region $A_{10}$, but followed by another doubling of the velocity in the second of these sequences $S_4$ at the region $A_{11}$ and followed again by almost a 50% reduction in velocity at the off-running side at $A_{12}$. It will be appreciated that the general cross-sectional area in each of the successive sequences $S_1$, $S_2$, $S_3$, $S_4$ involves a reduction, hence the general velocity increases all the way along. On top of this we have the superimposition of drastic velocity changes by virtue of either the abutment turbulence generators **40** and **41** or the shear turbulence generators **15** and **16**. The shear turbulence generators **15** and **16** generate a lower scale of turbulence but still give excellent fiber distribution and the desired fiber distribution for ultimate feeding to the exit channel X.

As mentioned hereinbefore, the overall channel R could have the general characteristics of the exit channel X if it had a great enough longitudinal dimension. The difficulty is that paper machines do not provide for this much space. Accordingly, it is necessary to add to the device for converting the cross-machine stock flow into longitudinally directed stock flow a certain number of turbulence generators which will greatly diminish the overall exit stage dimension X. These various turbulence generators **40**, **41**, **15** and **16** will not completely eliminate the exit stage X but they will reduce the dimension thereof materially and make the size of the machine workable for practical purposes. In developing turbulence generating systems which will do this, it has been found that at least the first two sequences $S_1$ and $S_2$ are preferably of the vortex generating type, as in the case of the rods **40** and **41**; whereas it has also been found that preferably the last two sequences here designated $S_3$ and $S_4$ are preferably of the shear or approximately shear generating devices in the sense that a lower scale of turbulence will be fed into the exit chamber X and a better fiber distribution is ultimately obtained at the slice **14**. Also, the drastic impingement in the initial chamber $R_c$ plus the vortex generation at the rods **40** and **41** will cause complete breakup of fiber clots and the like so that the random distribution of fibers in the stock that is desired will have been obtained, but the problem of maintaining this random distribution of fibers in the stock is not simple and also the problem of obtaining the desired cross-machine profile for longitudinal stock velocity is not simple and it has been found that these shear turbulence generating devices **15** and **16** are particularly useful at least as the last pair of turbulence generators just before the exit chamber X. The importance of the exit chamber has already been discussed. The nature of shear turbulence generators **15** and **16** has been discussed in considerable detail in, for example, the previously mentioned application Ser. No. 69,338 which need not be described in complete detail, since this and the other applications hereinbefore referred to are actually incorporated herein by reference. In essence, the purpose of a shear generator is to cause abrupt convergence followed by abrupt divergence (which would be from the area $A_8$ to the area $A_9$ during the abrupt convergence and from the area $A_9$ to the area $A_{10}$ for the abrupt divergence) in such a manner as to superimpose an abrupt velocity change upon the stock (although this velocity change is actually at a rate that is from 1/10 to perhaps 9/10 or 7/10 the rate of velocity change that is imposed by the upstream rod banks **40** and **41**). In addition, the purpose of shear generators is to minimize vortex type of turbulence generation by separation of the stock from the walls during the downstream or divergent flow of each sequence $S_3$ and $S_4$. Referring to the details of FIGURE 4, it will be seen that the angle of convergence **15***a* between the surface of the roof **11***c* and the turbulence generator **15** is approximately an angle of 15° in the device here shown. This is a relatively abrupt angle of convergence and a more gradual angle could be used ranging perhaps down to as low as about 3° to 5° and up to as much as about 20° for the more drastic conditions. On the other hand, the angle of divergence at the off-running side is of somewhat greater importance from the point of view of avoiding separation of the stock from the wall. In the turbulence generator **15** the angle of divergence **15***b* is also here indicated as being about 15°, although it may range from this approximate maximum down to as low as about 3° to 5° depending upon the speed of stock.

Departing briefly from the mechanics of shear turbulence generation here involved, it will be appreciated that as indicated in FIGURE 4, the roof **11***c* is provided with a pair of cross-machine slots into which the anchoring portions **15***c* and **16***c* of the turbulence generators **15** and **16** may be slipped and retained for ordinary operation. These devices are thus moved in and out of position by sliding the same in the transverse or cross-machine direction which is a convenient arrangement. The turbulence generators **15** and **16**, however, extend the full width of the channel section $R_2$ and although they are shown in FIGURE 4 in full view it will be appreciated that the longitudinal section at any location across the machine will be the same. As indicated in FIGURE 3, the actual cross-sectional dimension in the minimum area $A_{11}$ is slightly smaller than in the minimum area $A_9$ and in each case these dimensions are in a ratio to the dimension $A_{13}$ of approximately 1:4 to 3:4, so the velocities at the locations $A_9$ and $A_{11}$ are actually greater than the slice longitudinal stock velocity and this is desired for purposes of imparting a final shearing force to the stock approaching the slice **14**. As previously indicated, the floor **12***c* in the second section $R_2$ is at approximately an angle of about 2° to the horizontal or to the wire line indicated by the line marked W in FIGURE 4. The roof **11***c* which is a continuation of the roof **11***a* of the first section $R_1$ in the operating arrangement is approximately at an angle of about 5 or 5¼° to the wire line W, so that the angle of convergence in the preferred embodiment here shown is slightly over 3°. This means that the centerline plane for the channel R is a line indicated generally at P—P, which is really a centerline plane P—P that is used essentially for reference purposes. It will be seen that the convergence and divergence in the stock stream created by the shear generators **15** and **16** is not symmetrical with respect thereto and this seems to impart an improvement in the overall fiber distribution. In addition, it affords the mounting of the turbulence generators **15** and **16** only on the roof so that they may be swung in and out of operating position during maintennace and at other convenient times while still carrying out their essential and complete function when in operating position. The peak for the first of these sequences $S_3$ is the peak indicated at the apex of the triangular configuration at **15***d* for the shear turbulence generator **15**. This is not a sharp peak but a generally rounded peak and it is positioned a distance $L_2$ (FIGURE 2) that is approximately within the range of 2 to 5 times the dimension $M_3$ which is the center-to-center spacing in the upstream vortex turbulence generating rod bank **41**, so that the convergence will be maximized at

the region of incomplete turbulence decay from the upstream turbulence generating device, which in this case is the rod bank **41**. The same is true of the peak **16***d* for the downstream shear generator in that it also results in maximum stock convergence at a region of only partial decay from the upstream turbulence generator **15**.

With respect to the problem of shear generation, it must be appreciated that purely shear-turbulence generation does not permit any separation of the stock from the wall during the divergent flow. Thus in the region designated **15***e* and in the subsequent region of divergence designated **16***e*, the rapid flow of stock past the shear turbulence generators **15** and **16**, respectively, preferably does not result in separation from the channel walls or the channel roof **11***c* in this instance. It is known that in the case of relatively high speeds pure water will separate from a divergent wall if the angle of divergence from the centerline or center plane of the channel is greater than about 7°. In other words, in the case of pure water, if the angles indicated at **15***e* and **16***e* were greater than 7°, there would be separation of the pure water from the off-running side of the generators **15** and **16**. The angle of divergence **15***e* and **16***e* is represented in relation to the center plane P—P and the divergent trailing face **15***b* and **16***b* for the generators **15** and **16**, respectively, and it will be appreciated that in the construction here shown these angles of divergence **15***e* and **16***e* are at the maximum or perhaps somewhat above the maximum tolerated angle of divergence to completely avoid separation. It is known that stock with even relatively small percentages of fiber therein does not behave like pure water and it does not behave like a true fluid or liquid. Instead, it has peculiarities in behavior and it will not separate from the wall at an angle of divergence immediately above 7°, in fact, angles of divergence as high as 12, 13 or even 14° are permitted. In the present instance simple arithmetic will reveal that the angle of divergence **15***e* and **16***e* is approximately 13½° in each case. This is about the maximum tolerated for practical purposes. It may result in a slight amount of separation but it does not result in a significant amount of separation or a harmful amount of separation, particularly in view of the fact that the exit channel X is at least twice and preferably three times the longitudinal dimension $S_4$ of the last sequence of shear turbulence generation. In other words, these turbulence generators **15** and **16** are designed to obtain the maximum desired turbulence under the circumstances without causing any undesirable results at the ultimate slice **14** and this is done by using a rather drastic angle of divergence, preferably, in conjunction with a reasonably long exit channel X which has the description already given. It will be appreciated that the angle of divergence may be reduced from the indicated 13 or 14° down to as low as 3, 5 or 6° in certain instances and in the case of certain types of stock this is not a difficult problem since the generators **15** and **16** may be readily constructed so as to reduce this angle of divergence. The type of shear turbulence generators **15** and **16** here shown readily accommodates this type of change since the variable involves nothing more than adding to or subtracting from the material employed in the off-running side of the turbulence generator relative to the center plane P—P of the channel. Thus the channel itself may have its angle of convergence increased or decreased somewhat under certain circumstances, and this will involve a rather major change in the overall structure. On the other hand, by very nominal and relatively easily made changes the shear generators **15** and **16** may be altered to obtain whatever angle of divergence **15***e* and **16***e* may be desired or may be found to be desirable. Also, it will be noted that at the approach to the channel X there is a slight reduction from $A_{12}$ to $A_{13}$ in cross-sectional area and the stock does pass a rounded edge, indicated at $X_0$ in FIGURE 4 so as to obtain a slight additional turbulence generation by virtue of the rather abrupt change in cross-sectional area and thus abrupt velocity change at this very point. This serves to cooperate with the downstream sequence $S_4$ to afford the best fiber distribution and the best results in high speed machines.

Although specific aspects of the instant invention are described in our aforesaid prior applications, it will be appreciated that modifications may be made herein without departing from the spirit and scope of the instant invention.

We claim as our invention:

1. In a paper machine stock inlet of substantial transverse dimension for flowing stock in a longitudinal direction onto a forming surface traveling longitudinally at a predetermined speed, means defining a multiplicity of apertures positioned in generally transversely uniform pattern for generating a multiplicity of high speed stock jets lying generally in transverse alignment, means at the on-coming side of said apertured means for delivering stock at a substantially uniform pressure to the on-coming sides of said apertures for generation of substantially uniform stock jet speeds therethrough, transverse baffle means positioned at the immediate off-running side of said apertures receiving and turning the stock jets impinging thereagainst to impart transverse stock flow components thereto in a chamber having a transverse cross-sectional area substantially greater than the total aperture transverse cross-sectional area to effect substantial diminution of primary longitudinal stock flow velocity, a thin stock flow channel of substantially the transverse dimension of said chamber and having closely spaced walls merging smoothly with said chamber gradually converging longitudinally therefrom toward a slice outlet to effect a primary stock flow velocity increase toward the slice and stationary means in said channel defining a plurality of sequences of alternating minimum and maximum transverse cross-sectional areas for sequentially super-imposing distinct secondary stock flow velocity changes upon the primary stock flow to impart to the stock flowing in the channel small scale turbulence in a condition of partial decay at the slice, each such sequence having a longitudinal dimension extending from a maximum to and through the adjacent minimum and to the next maximum of such cross sectional areas, the upstream-most plurality of said sequences each being defined by a transversely extending bank of transversely spaced abutments with abruptly terminating downstream sides for vortex turbulence generation substantially upstream of the slice, there being a turbulence decay section of said channel of substantially the cross-sectional area of and immediately upstream from the slice, such section being defined by smooth wall portions extending longitudinally beyond the downstream sequence a substantially greater distance than the longitudinal dimension of such sequence.

2. In a paper machine stock inlet of substantial transverse dimension for flowing stock in a longitudinal direction onto a forming surface traveling longitudinally at a predetermined speed, means defining a multiplicity of small apertures positioned in generally transversely uniform pattern for generating a multiplicity of high speed stock jets lying generally in transverse alignment, means at the on-coming side of said apertured means for delivering stock at a substantially uniform pressure to the on-coming sides of said apertures for generation of substantially transversely uniform stock jet speeds therethrough, transverse baffle means positioned at the immediate off-running side of said apertures receiving and turning the stock jets impinging thereagainst to impart transverse stock flow components thereto in a chamber having a transverse cross-sectional area to effect substantial diminution of primary longitudinal stock flow velocity, a thin stock flow channel of substantially the transverse dimension of said chamber and having closely spaced walls merging smoothly with said chamber gradually converging longitudinally therefrom toward a slice outlet to effect a primary stock flow velocity increase toward the

slice and stationary means in said channel defining a plurality of sequences of alternating minimum and maximum transverse cross-sectional areas for sequentially superimposing distinct secondary stock flow velocity changes upon the primary stock flow to impart to the stock flowing in the channel small scale turbulence in a condition of partial decay at the slice, each such sequence having a longitudinal dimension extending from a maximum to and through the adjacent minimum and to the next maximum of such cross sectional areas, there being a turbulence decay section of said channel of substantially the cross-sectional area of and immediately upstream from the slice, such section being defined by smooth wall portions extending longitudinally beyond the downstream sequence a substantially greater distance than the longitudinal dimension of such sequence, and the channel being provided with a generally downwardly inclined roof portion in rigid assembly with the downstream most plurality of sequences and including the top wall portion of such turbulence decay section extending to the slice, said roof portion being swingably movable with the sequences in rigid assembly therewith to expose to ready access a smooth floor wall surface portion for said channel free from recesses tending to retain pools of undrained stock.

3. In a paper machine stock inlet of susbtantial transverse dimension for flowing stock in a longitudinal direction onto a forming surface traveling longitudinally at a predetermined speed, means defining a multiplicy of small apertures positioned in generally transversely uniform pattern for generating a multiplicity of high speed stock jets lying generally in transverse alignment, means at the on-coming side of said apertured means for delivering stock at a substantially uniform pressure to the on-coming sides of said apertures for generation of substantially uniform stock jet speeds therethrough, transverse baffle means positioned at the immediate off-running side of said apertures receiving and turning the stock jets impinging thereagainst to impart transverse stock flow components thereto in a chamber having a transverse cross-sectional area substantially greater than the total aperture transverse cross-sectional area to effect substantial diminution of primary longitudinal stock flow velocity, a thin stock flow channel of substantially the transverse dimension of said chamber and having closely spaced walls merging smoothly with said chamber gradually converging longitudinally therefrom toward a slice outlet to effect a primary stock flow velocity increase toward the slice and stationary means in said channel defining a plurality of sequences of alternating minimum and maximum transverse cross-sectional areas for sequentially superimposing distinct secondary stock flow velocity changes upon the primary stock flow to impart to the stock flowing in the channel small scale turbulence in a condition of partial decay at the slice, each such sequence having a longitudinal dimension extending from a maximum to and through the adjacent minimum and to the next maximum of such cross-sectional areas, the downstream-most plurality of said sequences each being defined by converging and diverging generally smooth merging wall portions for shearing effect turbulence generation substantially upstream of the slice, there being a turbulence decay section of said channel of substantially the cross-sectional area of and immediately upstream from the slice, such section being defined by smooth wall portions extending longitudinally beyond the downstream sequence a substantially greater distance than the longitudinal dimension to such sequence.

4. In a paper machine stock inlet of substantial transverse dimension for flowing stock in a longitudinal direction onto a forming surface traveling longitudinally at a predetermined speed, means having apertures defined by a multiplicity of generally parallel tubes of substantial length-to-diameter ratios of at least 7 to 1 positioned in generally transversely uniform pattern for generating a multiplicity of high speed stock jets lying generally in transverse alignment, means at the on-coming side of said apertured means for delivering stock at a substantially uniform pressure to the on-coming sides of said apertures for generation of substantially transversely uniform stock jet speeds therethrough, transverse baffle means positioned at the immediate off-running side of said apertures receiving and turning the stock jets impinging thereagainst to impart transverse stock flow components thereto in a chamber having a transverse cross-sectional area substantially greater than the total aperture transverse cross-sectional area to effect substantial diminution of primary longitudinal stock flow velocity, a thin stock flow channel of substantially the transverse dimension of said chamber and having closely spaced walls merging smoothly with said channel gradually converging longitudinally therefrom toward a slice outlet to effect a primary stock flow velocity increase toward the slice and stationary means in said channel defining a plurality of sequences of alternating minimum and maximum transverse cross-sectional areas for sequentially superimposing distinct secondary stock flow velocity changes upon the primary stock flow to impart to the stock flowing in the channel small scale turbulence in a condition of partial decay at the slice, each such sequence having a longitudinal dimension extending from a maximum to and through the adjacent minimum and to the next maximum of such cross sectional areas, the upstream-most plurality of said sequences each being defined by a transversely extending bank of transversely spaced abutments with abruptly terminating downstream sides for vortex turbulence generation substantially upstream of the slice, there being a turbulence decay section of said channel of substantially the cross-sectional area of and immediately upstream from the slice, such section being defined by smooth wall portions extending longitudinally beyond the downstream sequence a substantially greater distance than the longitudinal dimension to such sequence.

5. In a paper machine stock inlet of substantial transverse dimension for flowing stock in a longitudinal direction onto a forming surface traveling longitudinally at a predetermined speed, a chamber having such transverse dimension, a thin stock flow channel of substantially the transverse dimension of said chamber and having closely spaced roof and floor walls merging smoothly with said chamber gradually converging longitudinally therefrom toward a slice outlet to effect a primary stock flow velocity increase toward the slice and stationary means in said channel defining a plurality of sequences of alternating minimum and maximum transverse cross-sectional areas for sequentially superimposing distinct secondary stock flow velocity changes upon the primary stock flow to impart to the stock flowing in the channel small scale turbulence in a condition of partial decay at the slice, means defining a multiplicity of small apertures positioned in generally transversely uniform pattern for generating a multiplicity of high speed stock jets lying generally in transverse alignment and directed generally downwardly to impinge against said chamber floor wall upstream of said sequences to impart transverse stock flow components to such stock jets and turn the stock jet impinging on the floor wall through substantially a right angle and into the upstream-most of said sequences, and means for feeding stock under pressure to the top on-coming side of said apertured means.

6. In the inlet of claim 5, said stock feeding means receiving generally transversely aligned stock flow at one side of the inlet and diminishing transversely in longitudinal cross section for delivering stock at a substantially uniform pressure to the on-coming sides of said apertures for generation of substantially uniform stock jet speeds therethrough, and the total aperture transverse cross-sectional area being substantially less than the chamber transverse cross-sectional area for effecting substantial diminution in primary longitudinal stock flow velocity in said chamber.

7. In a paper machine stock inlet of substantial transverse dimension for flowing stock in a longitudinal direction onto a forming surface traveling longitudinally at a predetermined speed, a chamber having such transverse dimension, a thin stock flow channel of substantially the transverse dimension of said chamber and having closely spaced roof and floor walls merging smoothly with said chamber gradually converging longitudinally therefrom toward a slice outlet to effect a primary stock flow velocity increase toward the slice and stationary means in said channel defining a plurality of sequences of alternating minimum and maximum transverse cross-sectional areas for sequentially superimposing distinct secondary stock flow velocity changes upon the primary stock flow to impart to the stock flowing in the channel small scale turbulence in a condition of partial decay at the slice, means having apertures defined by a multiplicity of generally parallel tubes of substantial length-to-diameter ratios of at least 7 to 1 positioned in generally transversely uniform pattern for generating a multiplicity of high speed stock jets lying generally in transverse alignment and directed generally downwardly to impinge against said channel floor wall upstream of said sequences to impart transverse stock flow components to such stock jets and turn the stock jet impinging on the floor wall through substantially a right angle and into the upstream-most of said sequences, and means for feeding stock under pressure to the top on-coming side of said apertured means, said last mentioned means including a tapered cross-machine conduit above said tubes and means for feeding stock transversley into such conduit and maintaining stock flow speeds and pressures therein for delivering stock to the top of each such tube for generating substantially transversely uniform stock jet speeds in each of such tubes.

8. Apparatus for distributing particulate material in a liquid vehicle comprising a flow channel defined by transversely extending walls on opposite sides of a flow path center-line plane having therebetween a transversely elongated flow path narrow in dimension perpendicular to such transverse dimension, said walls extending continuously converging longitudinally in the direction of flow from an elongated narrow transverse vehicle opening to an elongated substantially more narrow transverse vehicle outlet downstream from the opening, intermediate said outlet and said opening, said walls defining successive downstream-wise smoothly merging successively more narrow channel sequences, the walls of each of such channel sequences being contoured to define a plurality of transversely extending, successive downstream-wise, smoothly merging alternating increasing and decreasing cross-sectional areas, with each such sequence constituting a longitudinal distance from one region of maximum cross-sectional area to a region of minimum cross-sectional area and to the immediate downstream next region of maximum cross-sectional area in the longitudinal direction, and such walls defining a final outlet portion beyond the last of such sequences between substantially smooth, substantially equally spaced wall portions, whereby localized increases and decreases in vehicle velocity are imposed at each of said sequences upon an average generally increasing velocity in the vehicle in the flow channel to effect turbulence generation in such vehicle by shearing effect as contrasted to vortex generation, and the final outlet section in such vehicle channel presents smooth walls for affording partial decay of such turbulence, such final outlet portion of the channel affording partial turbulence decay being of a longitudinal dimension at least as great as the longitudinal dimension of the last of such sequences immediately upstream therefrom.

9. Apparatus as claimed in claim 8 wherein each sequence region of minimum cross-sectional area is defined by off-set turbulence generating surfaces that are in the form of means presenting surfaces extending into the channel from only one of said walls opposite to a smooth surface generally flat wall surface.

10. Apparatus as claimed in claim 9 wherein such means extend only from a top channel wall opposite a flat bottom channel wall.

11. Apparatus as claimed in claim 10 wherein such outlet section has a longitudinal dimension greater than twice that of the immediate upstream sequence.

12. Apparatus for improving distribution of particulate matrial in a liquid vehicle, comprising a thin channel having a substantial transverse dimension and converging gradually longitudinally to effect a primary longitudinal flow velocity increase in a thin stream of such liquid vehicle flowing through such channel, means in said channel defining a plurality of longitudinally successive sequences of alternating minimum and maximum cross-sectional areas superimposing distinct secondary velocity increases and decreases on the primary vehicle flow velocity and generating turbulence in such stream, each such sequence having a longitudinal dimension extending from a maximum to and through the adjacent minimum and to the next maximum of such cross sectional areas, at least the last two downstream-most sequences being defined by converging and diverging generally smooth merging wall portions for shearing effect turbulence generation and, at least the two upstream-most sequences each being defined by transversely extending and spaced abutments individually terminating abruptly at the downstream side thereof for vortex turbulence generation, the average cross-sectional area of each such sequences decreasing in the donwstream direction, and a final outlet channel portion smoothly merging with the downstream-most of such sequences and extending longitudinally therebeyond for a longitudinal dimension at least as great as that of such sequence, such final outlet channel portion being defined by substantially smooth substantially equally spaced walls for affording partial decay of turbulence within the vehicle flowing therebetween.

13. Apparatus for improving distribution of particulate material in a liquid vehicle, comprising a thin channel having a substantial transverse dimension and converging gradually longitudinally to effect a primary longitudinal flow velocity increase in a thin stream of such liquid vehicle flowing through such channel, means in said channel defining a plurality of longitudinally successive sequences of alternating minimum and maximum cross-sectional areas superimposing distinct secondary velocity increases and decreases on the primary vehicle flow velocity and generating turbulence in such stream, each such sequence having a longitudinal dimension extending from a maximum to and through the adjacent minimum and to the next maximum of such cross-sectional areas, at least the last two downstream-most sequences being defined by converging and diverging generally smooth merging wall portions for shearing effect turbulence generation. The average cross-sectional area of each such sequence decreasing in the downstream direction, and a final outlet channel portion smoothly merging with the downstream-most of such sequences and extending longitudinally therebeyond for a longitudinal dimension at least as great as that of such sequence, such final outlet channel portion being defined by substantially smooth substantially equally spaced walls for affording partial decay of turbulence within the vehicle flowing therebetween; and vehicle feed means for such channel defining a plurality of transversely spaced stock jets impinging against a wall to define a vehicle stream turned by such wall at least about 90° and forced into such channel.

14. A paper machine stock inlet comprising a tapered cross-machine stock flow header, a multiplicity of downwardly directed tubes extending from the header and having a length-to-diameter ratio of 7:1 to 30:1 lying in generally spaced cross-machine alignment, a source of stock under pressure feeding stock into said cross-machine header to feed stock at a substantially transversely uniform pressure into the tubes, a channel defined by gradu-

ally converging closely spaced top and bottom walls converging at an angle of substantially 1° to 10° and having the bottom wall downwardly inclined at about ½° to 5° from the horizontal, the bottom wall of said channel extending directly beneath said tubes to receive and turn impinging stock jets therefrom through substantially 90° in a deceleration chamber and feed the stock into the inlet of said channel, said channel having a very thin stock inlet and the slice outlet of said channel being defined by smooth substantially equally spaced top and bottom wall portions having a predetermined longitudinal dimension, and said channel having intermediate the channel inlet and said slice outlet portion a plurality of sequences of alternating maximum and minimum cross-sectional area for superimposing distinct velocity changes on the stock flowing through each such sequence, each such sequence having a longitudinal dimension extending from a maximum to and through the adjacent minimum and to the next maximum of such cross-sectional areas, the downstream-most of such sequences being about ⅓ to ½ the longitudinal dimension of the aforesaid slice outlet.

15. A device as claimed in claim 14 wherein the two downstream-most sequences are shear-turbulence generators.

16. A device as claimed in claim 14 wherein the two upstream-most sequences are vortex-turbulence generators.

17. A device as claimed in claim 16 wherein the two downstream-most sequences are shear-turbulence generators.



18. A device as claimed in claim 17 wherein the tube open area, and the minimum open area at each of the downstream-most sequences is in each case about 50% to 100% of the slice open area.

19. In the inlet of claim 1, the downstream-most plurality of said sequences each being defined by converging and diverging generally smooth merging wall portions for shearing effect turbulence generation, as contrasted to said vortex turbulence generation at said upstream sequences.


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