The invention relates to the art of papermaking and more particularly to an up-flow type of headbox for use in conjunction with a papermaking machine.

In most papermaking machines the sheet or web is formed by bringing a paper stock comprising a pulp suspension into contact with a foraminous forming surface and permitting or causing the water of the pulp suspension to flow through the holes in the forming surface leaving a mat-like layer of fiber on the forming surface. The paper stock is usually supplied under a hydraulic head sufficient to cause a desired flow of stock to the forming surface and it has been common practice to obtain this head by employing an open top rectangular box, commonly called a headbox, in which a level of stock is maintained at a sufficient height above the forming surface to give the desired head.

As is well known, a paper stock is frequently composed of various components including water which has drained through the forming surface (commonly called white water), recirculated stock, and fresh incoming stock. It has also been common practice to mix the various components of the paper stock in the headbox. According to this practice each of the components is introduced into the headbox through a separate pipe and it has been assumed that the natural turbulence resulting from such a procedure would produce adequate mixing. However, this is not usually accomplished under present day operating conditions. Pockets of different consistency stocks tend to form in the corners of the headbox and this segregation causes streaks of uneven consistencies of stock to pass to the forming surface and cause irregularities in the sheet. These irregularities tend to produce blemishes in the formation, irregular caliber in finish across the sheet, and numerous operating troubles. It is also desirable to prevent the flow of other gaseous materials to be removed from the mixed stock before it passes to the forming surface. It has been assumed that adequate elimination of air could be obtained with the conventional type of headbox referred to above, whereas actually the extreme turbulence of the mixing operation in a normal headbox tends to increase the air content of the stock.

In a prior patent of the applicant, namely U.S. Patent 2,393,244, which issued January 22, 1946, one way of overcoming this problem was solved by providing an “up-flow” headbox comprising an outer inverted cone and an inner inverted cone concentric therewith and forming an annular space therebetween. The term “up-flow” may be one that is not generally known in the prior art and is descriptive of the flow arrangement shown in U.S. Patent 2,393,244. For the purpose of the present description it will be understood that “up-flow” headbox refers to a headbox having a flow arrangement of this type.

In the construction of U.S. Patent 2,393,244 stock was delivered so as to flow upwardly through the inner cone at a constantly decreasing velocity passing over a dam formed by the upper edge of the inner cone so that it flowed downwardly through the annular space between the two cones at a constantly increasing rate. Because of the upper direction of the flow of the incoming stock in the relatively low stock velocity at the overflow dam this form of headbox is well adapted to remove air and other gaseous materials from the stock and improve the smoothness of flow. However, in order to achieve the desired mixing step, this was undertaken by the provision of mixing devices incorporated in conduit lines leading from the papermaking machine. In other words, the mixing step and the air removal step were physically separated one from the other so that the mixing was accomplished before the stock reached the headbox and therefore did not interfere with the desired functions which are the maintenance of a constant flow level and the elimination of air or other gaseous material from the stock.

The present invention aims to provide an improvement on the conical “up-flow” type of headbox disclosed in U.S. Patent 2,393,244 by providing a means of directly mixing the various components of stock in the headbox, thus eliminating the necessity of the remote mixing devices, and at the same time eliminating the disadvantages of the commonly used type of headboxes with respect to the elimination of air or other gaseous materials.

The advantages of the headbox of the present invention may be best appreciated by reference to the accompanying drawings which illustrate a preferred form of the headbox incorporated in a paper machine of the cylinder type and in which:

FIGURE 1 is a diagrammatic view of an “up-flow” headbox-mixer construction in accordance with the present invention as combined with a paper machine of the cylinder type.

FIGURE 2 is a view corresponding to FIGURE 1 with the headbox, cylinder mold, vat, and flow spreader shown in section to illustrate the construction more clearly.

FIGURE 3 is a view of the upper portion of the headbox-mixer of FIGURE 1 along the line 3-3 to show the tangential placing of the vacuum conduit leading from the cylinder mold.

FIGURE 4 is a cross-sectional view of the lower portion of the headbox-mixer construction of FIGURE 1 along the line 4-4.

Referring to the drawings, and more particularly to FIGURE 1, there is shown a vat of generally rectangular shape indicated at 10 and containing a foraminous cylinder mold 12 rotatably supported by the bearings 13, only one of which is shown. The particular vat and cylinder mold shown is of the adjustable cylinder type as shown in the applicant’s U.S. Patent 2,658,428, November 10, 1953. The mechanism for rotating the cylinder mold 10 and the internal construction in general forms no part of the present invention and therefore is not shown in detail.

Stock is supplied to the vat 10 through a flow spreader 14 which is of such shape and cross-sectional area as to spread the flow of stock to the full machine width with substantially no change or with an increase in stock velocity. The type of flow spreader shown is that illustrated and described in the applicant’s copending application Serial No. 856,457, filed December 1, 1959.

Upon entering the vat 10 the stock passes through a conduit 38 (see FIGURE 2) to the outer vat circle space 40 which is formed by an outer vat circle 42 of generally cylindrical contour and an inner adjustable vat circle 44.

The outer vat circle 42 is secured to the vat ends and the vat circle 44 is adjustable by suitable means, for example as shown in the applicant’s U.S. Patent 2,658,428, as previously mentioned. From the vat circle space 40 the stock flows over the smoothly curved upper end 41 of vat circle 44 into the inner vat circle 43. The curved surface 41 is analogous to the known making boards and may be so described.

As the stock passes through the inner vat circle space 43 the cylinder mold 12 rotates in a counter-clockwise direction, as shown, and a portion of the water passes through the foraminous surface of the cylinder mold form-
ing a web of fibers on the surface of the mold which is removed from the top of the mold after it has emerged from the stock. The water passing through the mold, known in the art as white water, is removed in a manner as will be described later. In the preferred construction illustrated, a vacuum pipe 34 connected to the interior of the mold aids in the extraction of the water and picks up any white water which may be carried upward by the mold. The circulating excess stock from the vat circle space 43 passes over an adjustable dam (not illustrated) and over the back end 45 of the inner vat circle 44 and leaves the vat through a conduit or pipe 47 to be recirculated as hereinafter described.

The water which flows through the surface of the cylinder mold 12 is removed at the ends of the mold and flows into a white water compartment 51 at the ends of the vat. The white water compartment 51 is provided with adjustable dams (not illustrated) so that the portion of the white water that overflows these dams is the excess white water which flows from the white water compartment through a pipe 53 to a suitable point of disposal. The remainder of the white water, constituting the major portion thereof, is carried from the white water compartment through the pipe 55 where it is again divided, one portion flowing through the pipe 56 where it is mixed with new stock fed through a pipe 58 as a diluent with the new stock and white water passing to a pump 61, and then by the pipe 59 to the screen or screens (not shown).

Again with reference to FIGURE 1 and 2, the “up-flow” headbox-mixer construction of the invention comprises an outer inverted cone 22 and an inner inverted cone 20 concentric therewith and forming an annular space 23 therebetween. The bottom portion of the outer cone 22 is closed and stock delivered to the annular space 23 therebetween, as will be described in more detail later, proceeds about the annular space until it reaches the top of the inner cone 20 and out of the headbox to the flow spreader 14.

This mixer-headbox construction of inner and outer cones, in one preferred arrangement shown, is provided with a cover 30 to which a vacuum pipe 32 is connected and the vacuum pipe 34, as previously mentioned, extends from the suction connection of the cylinder mold to the upper portion of the headbox and enters the same tangentially so that any white water picked up by the vacuum line 34 will be discharged with the white water entering the “up-flow” headbox from the white water delivery pipe 55, as will be described in more detail later.

As shown most clearly in FIGURES 1 and 2, the new stock is delivered to the outer cone 22 through a conduit 60 leading from the screen or screens (not illustrated) and the white water is delivered to the outer cone 22 through the pipe 55. The circulating excess stock is also delivered to the outer cone 22 through the conduit 47. As shown in FIGURE 4, the white water and circulating stock are preferably introduced tangentially into the outer cone 22 so as to impart a circumferential motion to the stock being delivered thereto, thereby lengthening its travel and increasing its time within the headbox which further aids in air or gas escape. The new stock delivered from the conduit 60, in the preferred construction shown, enters the outer cone 22 substantially directly across the circumferential flow so as to impinge against the inner cone 20 and create a further turbulence aiding in the desired mixing action. The mixture of new stock, white water and circulating stock in a circumferential flow and at a decreasing velocity through the tapering annular space between the inner and outer cones is intimately mixed in this initial travel and again mixed and blended as they proceed downwards through the interior of the inner cone 20 at a gradually increasing velocity.

The mixed and deaerated stock passes from the inner cone 20 through a pipe 61 to the suction side of a vat pump 65 and from the vat pump 65 is delivered to the first pass of the flow spreader 14 through a pipe 67.

In the preferred construction shown the provision of the vacuum pipe 32 and the covering of the headbox acts to further eliminate any air or other gaseous material. Since the vacuum within the headbox is the same as that within the cylinder mold (common source) the level of stock within the headbox remains substantially the same as that within the cylinder mold regardless of the degree of vacuum applied. This is possible due to the headbox being on the suction side of the pump. The stock is delivered through the pipe 59 by the pump 65 to the flow spreader 14 has been intimately mixed and deaerated providing the necessary characteristics for a smooth and uniform flow through the flow spreader into the interior of the cylinder machine.

A further feature of the present construction arising out of the preferred vacuum arrangement described is that it provides a water separator for suction lines of cylinder molds. As previously described, there is a tendency for water within the interior of the cylinder mold to be picked up during its rotation and this is intensified when the machine is operated at higher speeds. As the present vacuum connection from the mold to headbox picks up this water and returns to the system, in a tangential manner so that it does not splash down and entrain air, there is no loss of water except the normal run off of the excess, insuring stability of operation. This is particularly applicable to a system permitting vacuums on the order of several inches of mercury vacuum (about from 1 to 5 inches mercury or more) as is possible in the type of cylinder mold shown in applicant's U.S. Patent 2,509,296, issued May 30, 1950.

As can be clearly seen in FIGURES 1 and 2, the flow system illustrated is a gravity feed with the circulation being from screens and cylinder vat to the outer cone 22, mixed and deaerated within the annular space 23 and out of the inner cone 20 to the suction side of the vat pump 65 where the flow is given sufficient pressure to pass through the flow spreader 14 into the cylinder vat 10. The height of the top of the inner cone 20 is maintained substantially level with the bottom of the cylinder mold 12. By this arrangement the stock is initially mixed at the lowest point of the headbox where the velocities are greatest and is forthwith from the free surface to an air entainment. Further, as the stock progresses towards this free surface the speed of flow is decreased permitting the air to work through as the circulating flow decreases in velocity till at its slowest point at the air surface it progresses down through the center of the inner cone 20 and the flow increases in speed as it proceeds to the suction side of the pump. To avoid any accumulation of residual air the pipe 67 leading from the vat pump 65 is sloped upwardly and a vent pipe 69 leads from the top of this run directly into the white water pipe 55. A similar vent pipe 70 leads from the top of the first turn-around of the flow spreader 14, also to the pipe 55. The white water pipe 55 is also inclined upwardly towards its connection with the outer cone 22 so that any air travels upwardly into the outer cone 22 and is discharged during the upward movement of the stock.

While the preceding description and accompanying drawings refer to a preferred construction adapted for use in connection with a suction type cylinder machine, it will be appreciated that the “up-flow” mixer-headbox construction of the invention is suitable for use in combination with other standard types of cylinder machines. If the stock as it passes upwards through a standard cylinder mold arrangement without vacuum the cover 30 and vacuum pipes 32, 34 would not be necessary.

I claim:

1. In a paper machine of the type wherein a sheet is formed by bringing a paper stock into contact with a forming surface, a combined headbox-mixer comprising: a vertically arranged outer conduit having a cross-sectional area that increases gradually and continuously from
the bottom of said outer conduit to adjacent the top of said outer conduit, an inner conduit vertically arranged within said outer conduit and having a cross-sectional area that increases gradually from the bottom of said inner conduit to the top of said inner conduit; said inner and outer conduits being coaxially arranged with the tapering annular space therebetween constituting a mixing chamber, the upper edge of said inner conduit serving as an overflow means, means for supplying stock to the said mixing chamber between said inner and outer conduits at a point near the bottom of said outer conduit, and means for withdrawing stock from said inner conduit at a point near the bottom of said inner conduit, whereby stock delivered to said outer conduit flows upwardly in a spiral path through said mixing chamber at a gradually decreasing velocity, over said overflow means into the inner conduit and all the stock passing over said overflow means flows downwardly through said inner conduit at a gradually increasing velocity.

2. A machine as claimed in claim 1, wherein at least part of said stock is delivered tangentially into the lower portion of said mixing chamber.

3. In a paper machine of the type wherein a sheet is formed by bringing a paper stock into contact with a forming surface, a combined headbox-mixer comprising: a vertically arranged outer conduit having a cross-sectional area that increases gradually and continuously from the bottom of said outer conduit to the top of said outer conduit, an inner conduit vertically arranged within said outer conduit and having a cross-sectional area that increases gradually from the bottom of said inner conduit to the top of said inner conduit, whereby inner and outer conduits being coaxially arranged with the annular space therebetween constituting a mixing chamber, the upper edge of said inner conduit serving as an overflow means, the upper and lower ends of said outer conduit being sealed and a vacuum means connected into said outer conduit, means for supplying stock to the said mixing chamber between said inner and outer conduits at a point near the bottom of said outer conduit, and means for withdrawing stock from said inner conduit at a point near the bottom of said inner conduit, whereby stock delivered to said outer conduit flows in a spiral path upwardly through said mixing chamber at a gradually decreasing velocity, over said overflow means into the inner conduit and all the stock passing over said overflow means flows downwardly through said inner conduit at a gradually increasing velocity.

4. A machine as claimed in claim 3, wherein at least part of said stock is delivered tangentially into the lower portion of said mixing chamber.

5. In a cylinder machine having a cylinder mold mounted for rotation within a cylinder vat, a system of combining, mixing, deaerating, and delivery of dilute stock to said cylinder vat, including a headbox-mixer construction of combined inner and outer casing of tapering conical form, said headbox inner and outer casings being concentrically spaced one within the other with the upper larger end of said inner casing terminating below the upper larger end of said outer casing, a white water delivery conduit leading from said cylinder vat to the lower end of said outer casing, a recirculating stock delivery conduit leading from said cylinder vat to the lower end of said outer casing, a fresh stock delivery conduit leading from a source of supply to the lower end of said outer casing, the inner terminal ends of said white water, recirculating stock, and fresh stock delivery conduits being circumferentially spaced within said outer casing lower end, said inner casing lower end having a discharge outlet, a dilute stock discharge conduit leading from said inner casing discharge outlet, a pump having its suction side connected to said dilute stock discharge conduit, and a dilute stock flow spreader connected to the discharge side of said pump, said flow spreader leading into said cylinder vat, whereby separate streams of white water, recirculating stock and fresh stock are combined and caused to flow a spiral path upwards between said inner and outer casings at a gradually decreasing velocity up to the said upper end of said casing and down through said inner casing at a gradually increasing velocity to discharge as mixed, deaerated, dilute stock, and by said pump delivered through said flow spreader to said cylinder vat.

6. A system as claimed in claim 5, including a cover connected to said outer casing, a conduit extending between said cover and cylinder mold, and a connection to said cover from a vacuum pressure source.

7. The method of forming a fibrous web from dilute stock on a cylinder mold of a cylinder paper machine, comprising the steps of delivering the white water leaving the mold, fresh stock and recirculated stock in separate streams to a common mixing zone having an entry point and a discharge point, combining said streams at said mixing zone entry point and confining said combined streams within said mixing zone to follow a spiral flow path raising at a gradually decreasing velocity to a predetermined point of maximum area within said zone and from said point descending at a gradually increasing velocity to said zone discharge point thereby simultaneously intimately mixing and deairing said combined flow of white water, fresh and circulated stock, and from said mixing zone discharge point delivering said mixed, deaerated, diluted stock to the cylinder mold.

8. The method as claimed in claim 5, including the additional step of applying a vacuum to said mixing zone above said predetermined point of maximum area.

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