March 6, 1956 W. T. BENNETT 2,737,087

HEADBOX FOR PAPER MACHINE

Filed April 25, 1950 2 Sheets-Sheet 1

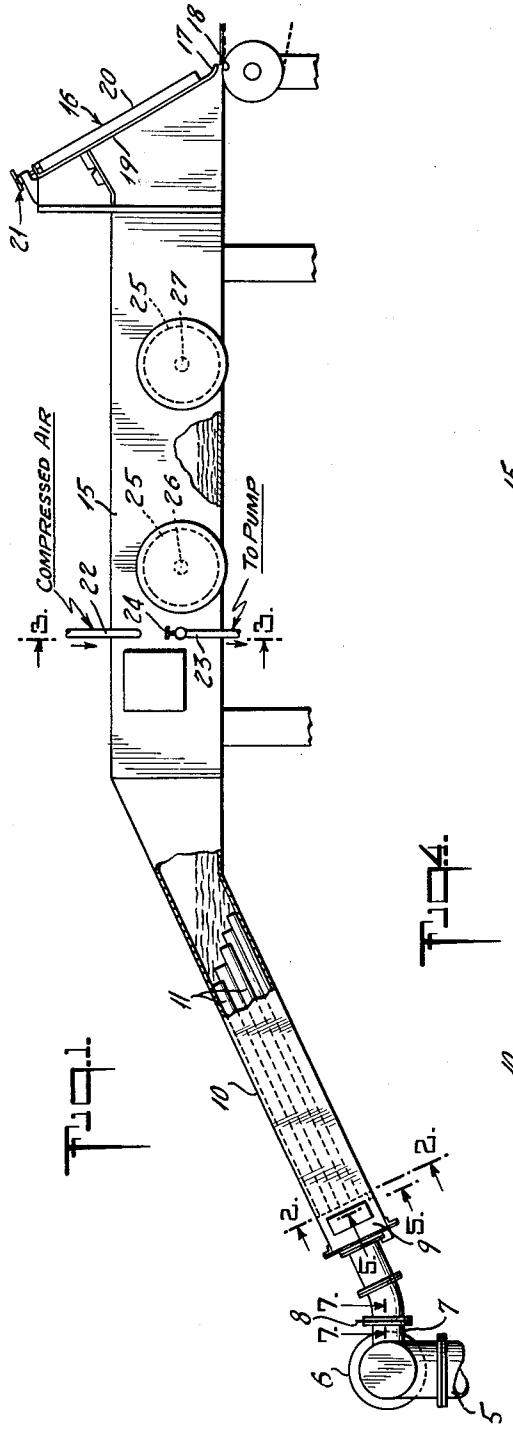


FIG. 1.

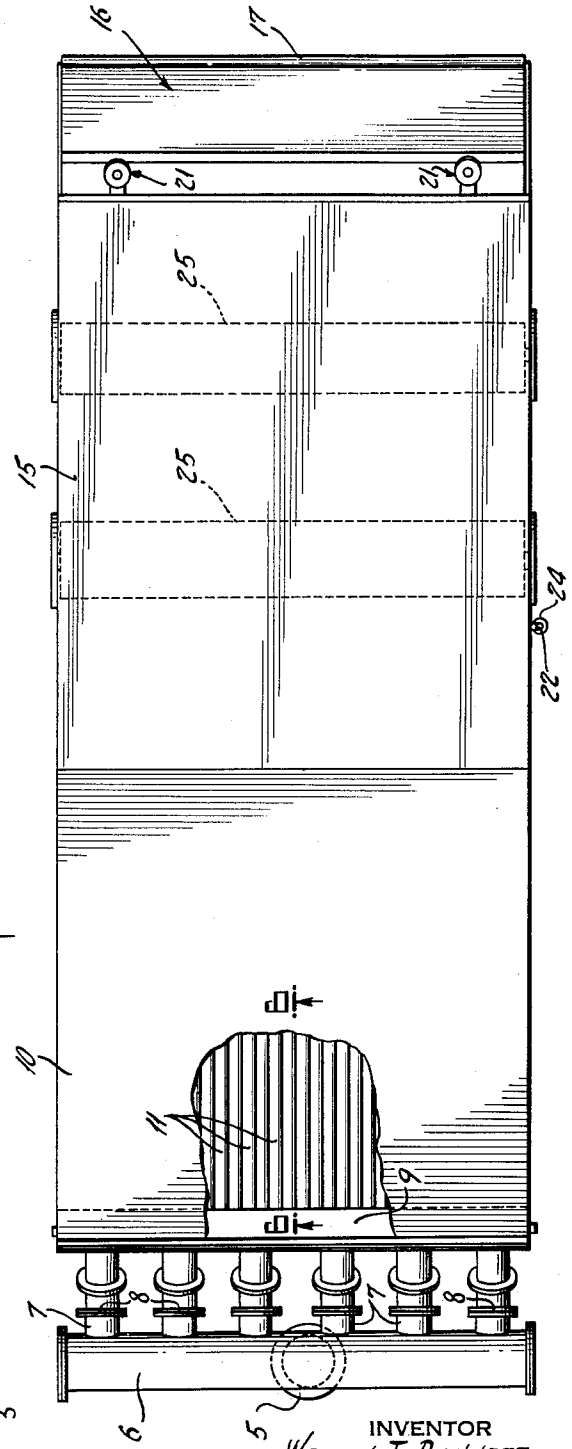


FIG. 4.

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HEADBOX FOR PAPER MACHINE

Filed April 25, 1950 2 Sheets-Sheet 2

Fig. 2.

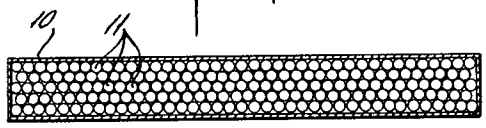


Fig. 3.

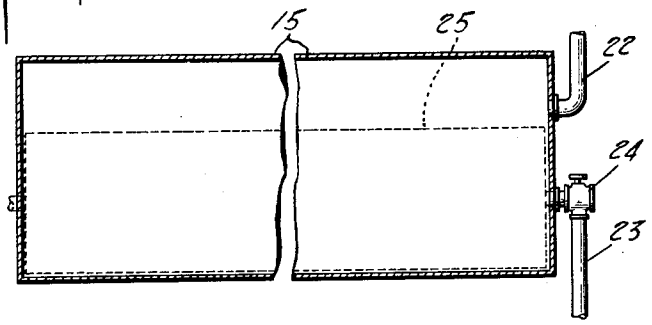


Fig. 7.

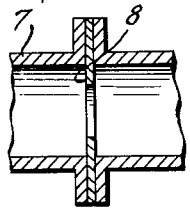


Fig. 5.

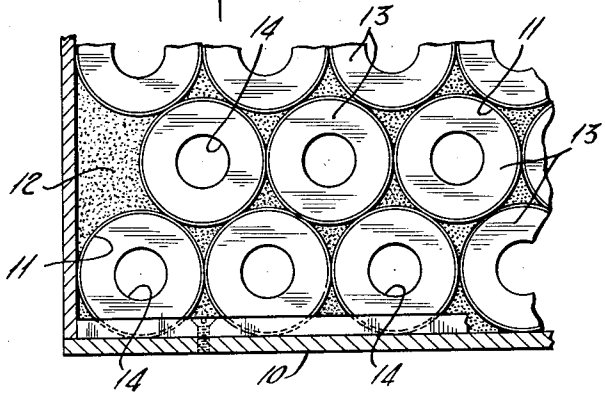


Fig. 6.

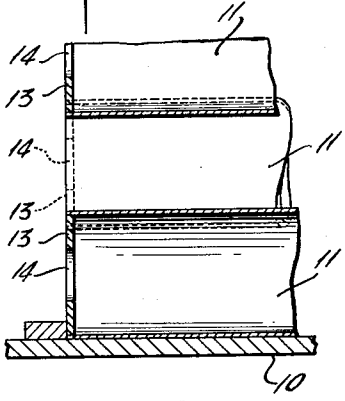
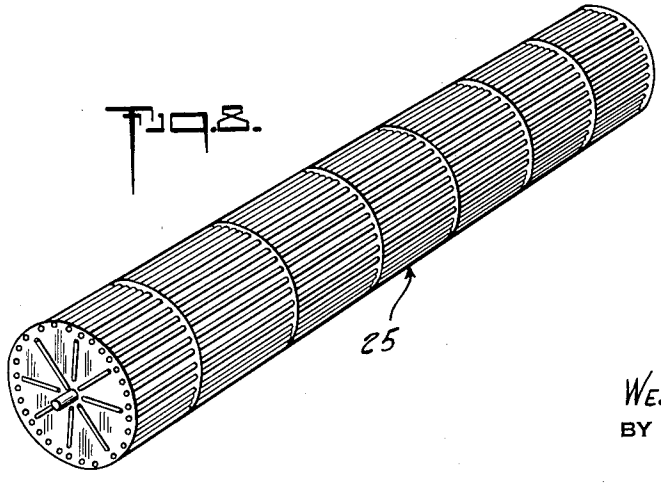


Fig. 8.



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HEADBOX FOR PAPER MACHINE

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Application April 25, 1950, Serial No. 157,869

10 Claims. (Cl. 92—44)

This invention relates to new and useful improvements in a method of and apparatus for flowing an aqueous woodpulp suspension onto the wire of a high speed papermaking machine and particularly seeks to provide a novel method of physically conditioning the pulp suspension so that it will be deposited on the wire of a paper machine under the most advantageous conditions of flow and novel apparatus by which such physical conditioning of the pulp suspension can be effected.

An object of this invention is to provide a novel method of physically conditioning the flow of woodpulp in aqueous suspension through the headbox of a papermaking machine whereby the stock as it approaches the slice will have its suspended fibres substantially in fixed relation with respect to one another throughout the major cross-sectional area of the flowing stream.

Another object of this invention is to provide a method of the character stated in which the stock suspension is progressively converted from a condition of turbulent flow to a condition of substantially frozen flow, which latter condition is achieved prior to the time at which the stock is projected through the slice.

A further object of this invention is to provide a method of the character stated in which any substantial amount of flocculation which may occur in the stock simultaneously with the establishment of frozen flow conditions may be broken up without disrupting the improved stock formation as the suspension passes through the slice.

A further object of this invention is to provide apparatus comprising a headbox for high speed paper machines so designed that the flow conditions of a woodpulp stock suspension entering it will be progressively converted from turbulent flow to frozen flow prior to the moment at which such stock is projected through the slice.

A further object of this invention is to provide apparatus of the character stated which includes a plurality of distribution pipes extending into open communication with a receiving chamber formed in the inlet portion of a flow box of generally rectangular cross-section and being provided adjacent the receiving chamber with a plurality of closely packed tubes sealed together in such a manner that all of the stock suspension must pass through the tubes.

A further object of this invention is to provide apparatus of the character described in which the closely packed tubes extend into open communication with a generally horizontal straight channel portion provided with one or more air inlets and fluid level control devices whereby to maintain the stock flowing through the channel portion under substantially constant condition of pressure and fluid level.

A further object of this invention is to provide apparatus of the character stated in which an adjustable slice is provided at the discharge end of the straight channel portion for effecting the smoothly controlled projection of the stock onto the wire of the papermaking machine.

With these and other objects in view, the nature of

which will be more apparent, the invention will be more fully understood by reference to the drawings, the accompanying detailed description, and the appended claims.

In the drawings,

Fig. 1 is a side elevation, partly in section, of a headbox constructed in accordance with this invention;

Fig. 2 is a transverse section taken along line 2—2 of Fig. 1;

Fig. 3 is a transverse section taken along line 3—3 of Fig. 1;

Fig. 4 is a top plan view of the headbox;

Fig. 5 is an enlarged detailed transverse section taken along line 5—5 of Fig. 1 and more clearly shows the exact arrangement of the tubes;

Fig. 6 is an enlarged detailed longitudinal section taken along line 6—6 of Fig. 4 and shows the exact manner of installation of the orfice plates at the intake ends of the tubes;

Fig. 7 is a horizontal detailed section taken along line 7—7 of Fig. 1; and

Fig. 8 is a perspective view of a deflocing roll which may be employed in connection with the instant form of headbox.

In dealing with water and other similar homogeneous fluids it is well known that the flow in a long, straight pipe or other similar channel of uniform cross-sectional area may be either turbulent or streamline, depending chiefly on the velocity of flow, the cross-sectional area of the channel and the viscosity of the liquid handled. The tendency for a fluid to assume either a streamline or a turbulent flow may be estimated by determining the "Reynolds number." Various investigators have determined that if the Reynolds number is below 2,000 the flow will normally be streamline, and if the Reynolds number exceeds about 4,000 it will normally be turbulent. Between these two numbers the tendency for a fluid to assume either streamline or turbulent flow is usually indeterminate.

In the paper industry, to which this invention specifically relates, headbox stock consists of a suspension of papermaking fibres in water and is, therefore, not a homogeneous fluid. Since normal dilution for paper machines is of the order of 3 to 10 lbs. of fiber per 1,000 lbs. of water, paper machine designers have assumed that flowing headbox stock behaved like water and testing of headbox and slice designs has normally been carried out using water containing small amounts of aluminum powder or other materials for observing flow characteristics.

It has been discovered that, under suitably controlled conditions the behavior of a stock suspension is entirely different from water, that it is thixotropic in nature and that conditions of flow can be created with characteristics different from either turbulent or streamline flow and which will be henceforth called "frozen flow."

Since headbox stock usually contains in excess of 99% water, the viscosity of such stock varies with temperature as might be expected in accordance with the laws governing the viscosity of water. However, the variations in viscosity of water with variations of headbox temperature customarily employed do not exceed the range from 0.3 to 1.0 centipoise. It is difficult to measure accurately the variations in viscosity of flowing stock with changes in velocity, but enough measurements have been made to show definitely that there is a critical velocity at any given temperature and consistency (lbs. of stock per lb. of stock and water) above which flow will be turbulent and the apparent viscosity will be very close to that of water, and below which flow may be streamline or frozen and the apparent viscosity varies inversely as the velocity. Variations in the apparent viscosity of flowing headbox stock inversely related to velocity have been

measured between 1.0 and 27.0 centipoises when the viscosity of the water alone was held constant at 0.91 centipoise, and it is obvious from examination of the test results that only physical limitations of the test apparatus prevent taking measurements at very low velocity which would show apparent viscosities well in excess of 27.0 centipoises. This very marked increase in apparent viscosity at velocities below the critical appears to be related to the amount of surface area exposed by the fibres and therefore, as would be expected, the apparent viscosity tends to increase with consistency, all other conditions being held constant. Also, it has been found that the critical velocity, at which the apparent viscosity approximates that of water, decreases with decreasing consistency, but the apparent viscosity may still be 10 to 20 times the viscosity of the water at moderately low velocities such as 0.5 foot per second when the consistency has been decreased to approximately 0.5%.

The Reynolds number referred to above may be determined by the following formula:

$$R=\frac{DVp}{u}$$

where:

R is the Reynolds number
D is the diameter
V is the velocity
p is the density
u is the viscosity

or for streams of non-circular cross-section as—

$$R=\frac{4W}{Lpu}$$

where:

W is the weight rate of flow
Lp is the wetted perimeter of a cross-section of the passage
u is the viscosity

Prior to this invention, in handling water or a stock suspension whose viscosity approached that of water, with commercial sizes of pipes or headbox channels, and at velocities normally employed, the flow was always turbulent, and the Reynolds number correctly indicated this condition of flow by working out to a figure of 50,000 or more. However, in accordance with this invention, if advantage is taken of the thixotropic behavior of stock suspensions at velocities which, dependent on consistency and temperature, are below 1.0′ to 3.0′ per second, it has been found that the tendency of a fluid to assume either turbulent or streamline flow, as expressed by the Reynolds number, has direct application in dealing with headbox and slice performance.

When applying the Reynolds formula to headbox design it must be kept in mind that the Reynolds number is partially determined by viscosity and that in a flowing stock suspension the viscosity is mainly dependent on velocity. Therefore, if turbulence exists in a flow whose average velocity is well below the critical, localized turbulent areas will have localized velocities well above the average, with correspondingly lesser viscosities. Under these conditions the Reynolds number for the average condition may be only indicative of a tendency to assume a streamline or turbulent flow and there may be insufficient time as the stock flows through a channel to actually reach this condition.

Turbulent flow, usually occurring when Reynolds numbers are in excess of 2,000, is characterized by irregular whirling eddies within a fluid, unstable and yet continuously reforming. In a stock suspension whose average velocity of flow, as determined from flow rate and cross-section of channel, is low enough to indicate a high apparent viscosity, the velocity within eddies may be high enough to reduce the viscosity close to that of the water, and there is, therefore, a tendency for the eddy current to persist.

Streamline flow, usually occurring when Reynolds numbers are less than 2,000, is characterized by the flow of a fluid within a tube such that each filament of liquid flows in a straight line, parallel to the axis of the tube, moving at progressively higher velocity as the center of the tube is approached. It seems doubtful that a stock suspension whose consistency is suitable for headbox stock, can ever flow in a streamline condition.

Frozen flow of a stock suspension occurs when Reynolds numbers are below 2,000 and when eddy currents persisting from a previously turbulent flow have been dissipated. It is characterized by a thin shear zone adjacent to any surface of the channel contacted by the stock in which the fibres tend to roll or shear past one another, while all the rest of the cross-section of the flowing suspension appears to be frozen into a solid moving parallel to the axis of the channel and with uniform velocity throughout its cross-section. With little or no movement of the fibres in relation to one another within a frozen flow the gathering together of the fibres into flocs takes place very slowly or not at all.

When paper machine stock at normal headbox consistencies flows in smooth channels, the tendency for the suspended fibres to gather together and form flocs is dependent chiefly on the nature of the flow. In a turbulent flow, the tendency of the fibres to floc is continuously overcome by the shearing action of eddy currents. In a frozen flow the only forces acting on the fibres to gather them together in flocs are the presence of air causing air lift or differences in specific gravity of the fibres and the water.

It is the function of a paper machine headbox to take a number of streams from individual screens or to take stock from one or more pipes and to deliver this stock in a suitable condition to the slice orifice. It is impossible to create a completely stable jet from a slice orifice when the flow to the orifice contains turbulence, and a stable jet containing well defined flocs is unsuitable for making a uniform sheet of paper. The function of the slice used in conjunction with a headbox is to increase the velocity of flow to a controllable velocity about equal to the speed of the fourdrinier wire and usually in the form of a free jet of predetermined width and controlled depth. Many designers have had as their objective the production of a jet issuing from the slice orifice more or less parallel to the wire, usually slightly above the wire, and free from turbulence which will cause subsequent disturbance to uniform formation on the wire. To avoid excessive floc formation within the headbox the flow approaching the slice orifice has invariably been turbulent with the result that turbulence persists through the orifice and in the free jet and out onto the wire, causing jumping, streaks, weaving and other disturbances to uniform formation. A perfectly stable jet can only be produced if the slice orifice is supplied with a "frozen" flow, and such a jet will maintain its stability, if free in the air, for several feet after issuing from the slice at jet speeds of the order of 700 to 1,700 feet per minute or more.

It follows, therefore, that the present invention is specifically directed to a method of and apparatus for so controlling the flow of paper stock or a pulp suspension that its flow characteristics will be changed from a condition of full, turbulent flow to a condition of frozen flow, first by passing the pulp suspension from a receiving chamber through a plurality of restricted passages, then by conducting all the suspension through a single channel to establish frozen flow conditions, and finally to project the frozen flow stock suspension through the slice onto the wire of a papermaking machine.

Referring to the drawings in detail, it will be seen that in one embodiment of apparatus constructed in accordance with this invention a main supply pipe 5 which carries incoming stock is connected to the central part of a transversely positioned header 6 having a length

slightly greater than the width of the wire of the associated papermaking machine. The stock flowing through the header **6** is flowing at a reduced rate and evenly discharged therefrom through a plurality of upwardly slanting discharge pipes **7** (see Figs. 1 and 7 of the drawings), each of which is provided with an orifice plate **8** of reduced diameter in order properly to regulate and temporarily accelerate the flowing stock, as will be hereinafter more fully described. The stock will of course decelerate after passing the orifice plates **8** since the orifice areas are less than the cross-sectional areas of the pipes **7**. Stock from the pipes **7** is discharged under turbulent flow conditions into a transversely disposed, rectangularly cross-sectioned chamber **9** which functions as the entrance portion of the headbox proper .

The headbox proper comprises an upwardly slanting, rectangular cross-sectioned channel portion **10** formed from sheet metal and having a width approximately equal to the width of the wire of the associated papermaking machine and a depth determined in accordance with the volume and rate of flow of stock adapted to be handled for any given set of operating conditions. The interior of the channel portion **10** is filled with a plurality of tiers of relatively small diameter pipes **11** disposed in parallelism with the longitudinal axis of the channel **10** and spot-welded together. The voids between the exteriors of the pipes **11** adjacent the ends thereof are completely filled as by suitable cement **12**, as indicated in Figs. 2 and 5 of the drawings.

The lower end portion of the channel **10** together with the intake ends of the pipes **11** defines the transverse chamber **9**. Each pipe **11** at its intake end is provided with an orifice plate **13** having an orifice **14** of reduced diameter (see Figs. 5 and 6 of the drawings) to effect a temporary acceleration of the stock followed by a deceleration thereof within the pipe. The pipes **11** as illustrated are of varying lengths with those on the lowermost tier being the longest and those on the uppermost tier being the shortest, but the average length of all of the pipes bears a definite relation to their diameter, as will be hereinafter more fully described.

The upper or discharge end of the channel **10** joins a relatively long, horizontally disposed channel portion **15** within which frozen flow stock conditions become established. The channel **15** is formed from sheet metal having a smooth inner surface and is provided at its discharge end with an adjustable slice assembly generally indicated at **16**. The slice assembly **16** itself may be of any suitable construction, but in order properly to follow the principles of this invention in its presently illustrated embodiment the included angle between the flat portion of adjustably positioned slice lip **17** and the horizontal apron **18** should be restricted to a maximum of 45° when using a depth of stock flow in the channel **15** of the nature to be hereinafter described. It will, of course, be appreciated that variations in the maximum permissive included angle between the slice lip and apron may be provided for in order to conform to changes resulting from variations in one or more operating factors.

While the mechanical details per se of the slice mechanism form no part of the present invention it will be appreciated that its construction will be of such a nature that the assembly which has generally been indicated at **16** includes stationary mounting elements **19** which slidably support slice lip carrying elements **20** which are adapted to be securely but adjustably positioned in any desired operation location with respect to the apron **18** as by adjusting screw and hand wheel assemblies generally indicated at **21**.

In the illustrated embodiment of the invention the headbox is shown as would be fabricated to operate as a pressure headbox in which the depth of flow of the pulp suspension in the horizontal channel **15** is less than the over-all depth of the channel. When such a design is employed means are provided for maintaining air pressure in that portion of the channel **15** above the flowing pulp suspension and in the present instance comprises an inlet pipe **22** opening into the channel **15** and connected with a suitable source (not shown) of compressed air. In order that proper control may be effected on the stock flowing under air pressure through the channel **15**, including control of the depth of flow and the corresponding velocityof the stock in the channel, a bleeder pipe **23** of relatively small diameter is affixed to one wall of and opens into the channel **15** at a height substantially equal to the designed depth of flow of the stock suspension. An adjustable valve **24** generally will be provided so as to restrict the leakage of compressed air, and the discharge side of the valve **24** may be connected to the wire pit of the paper machine.

The principles of this invention will also be followed where the channel **15** has a depth only sufficient to provide for any given width of channel a cross-sectional area and flow capacity that will properly receive the discharge from the multiple pipes **11** of the channel **10**.

Under normal operating conditions employed in making newsprint, either with or without deaerated headbox stock, just as the last of the turbulence is dissipated prior to establishing a condition of frozen flow, some flocculation of the fibres may occur, resulting in a floc pattern which will be retained through the slice orifice and in the paper. In the event that this floc pattern contains flocs of objectionably large size this invention also provides means for deflocing by creating a condition of mild turbulence in the flow which will subsequently resume a state of frozen flow before the slice is reached. To this end a rotatable cage-type of deflocing roll, generally indicated at **25** (see Fig. 8 of the drawings), may be transversely positioned within the horizontal channel **15** with its axis of rotation located as at **26** or **27** and driven by suitable power connections (not shown). In either of the suggested positions of the deflocing roll **25** it will serve to break up any floc formation while still permitting the stock to resume frozen flow stream characteristics as the stock reaches the slice and is projected therethrough.

In determining the dimensions of the various parts of a headbox constructed in accordance with this invention and the velocity adjustments and channel flow restrictions necessary to practice the method of handling a stock suspension in accordance with this invention, many factors must be taken into consideration, and it is believed that the following will serve as an example.

In applying the principles of this invention the most important considerations effecting the mechanical design and operational factors of the method include (*a*) the kind of stock, especially fibre size and surface area; (*b*) consistency of the stock suspension (weight of bone dry fibre relative to the weight of fibre plus water); (*c*) degree of turbulence and average velocity of flow into the headbox; (*d*) rate of flow through the box per unit of width; (*e*) average velocities used throughout the headbox; (*f*) the general nature of the devices to be used for quickly converting the stock from turbulent flow to frozen flow; (*g*) maximum wire speed and corresponding desired jet velocity and head at the slice; (*h*) smoothness of the surfaces which the stock will contact; and (*i*) the temperature of the stock suspension.

Keeping the foregoing factors in mind, the specifically disclosed embodiment of the invention may be considered as co-related to the following factors: (*a*) a newsprint grade of stock consisting of about 80% groundwood pulp and 20% sulphite pulp; (*b*) headbox consistency about 0.60%; (*c*) a single delivery pipe to the header **6** with an average flow velocity not exceeding 6.0 F. P. S.; (*d*) a maximum designed rate of flow through the headbox and slice of 1.00 C. F. S. per foot of slice width; (*e*) a maximum wire speed of 1200′ per minute with a jet velocity through the slice of about 18′ per second under a pressure

head equivalent to about 60" of water; and (*f*) a stock temperature of about 100° F.

Under the above operating requirements, for example, the single supply pipe 5 for first receiving the incoming stock could be of 20" diameter and the header 6 with which it connects would be of 18" diameter to provide a split flow in the header having an average maximum velocity of about 3.67' per second. The discharge pipes 7 would be 10" in diameter with an average maximum velocity of 4.0' per second and the orifice plates 8 thereof will serve to assure uniform distribution at an average maximum velocity of 6.0' per second through the orifices. The remainder of the length of these pipes in this specific embodiment would be not less than 30" between the orifices and the chamber 9. The stock discharges into the chamber 9 under conditions of highly turbulent flow. However, the average velocity corresponding or relative to the cross-sectional area of the chamber 9 is low.

From the chamber 9 the stock is forced through the pipes 11 which under the above-mentioned operating conditions will be 4" in diameter, and their orifice plates 13 will have their orifices 14 of a diameter such as to provide a velocity of 6' per second therethrough. It should be noted at this point that part of the velocity head of flow through the orifices 14 is converted to static head in the pipes 11 and probably within a distance equal to eight diameters. Experience has indicated that the pipes 11 should have an average length of twenty-two to thirty diameters in order that the principles of this invention may be properly followed. The unconvertible portion of the velocity head in the pipes 11 is present in the form of turbulence, the kinetic energy of which is nearly all dissipated by friction with the walls of the pipes 11 before the stock leaves the discharge ends thereof. The flow leaving the pipes 11 is still turbulent, but the kinetic energy remaining is relatively small so that the flow is in a condition to "freeze" readily and will do so. It may be of some interest to note at this point that it is extremely doubtful that any so-called "streamline" flow can take place under these operating conditions, but even if such could possibly be effected this invention is directed to the setting up of "frozen flow" conditions at least by the time the stock is ready to be projected through the slice. In the horizontal channel 15 the most favorable condition for "freezing" the stock has been found to exist when there is a moderate acceleration of the stock at the entrance to the horizontal channel, and it is believed that the present design effects this, although the most important end result is to have frozen flow at the slice regardless of the exact conditions of acceleration, etc. at the entrance of the horizontal channel 15. Under the operating conditions and apparatus proportions above described it has been found that the flow of stock becomes frozen within an average distance of 6' from the discharge ends of the pipes 11 when the stock flow depth in the channel 15 is maintained at 8" with a corresponding average flow velocity of 1.50' per second.

From the last statement above it will be appreciated that in the illustrated embodiment of apparatus the bleeder pipe 25 will be positioned about 8" above the bottom of the channel 15 so that its axis is substantially even with the surface of the flowing stock.

In the event it is desirable to use a headbox utilizing the principles of this invention but without a partially submerged deflocing roll or the use of compressed air over the flowing stock in the horizontal channel the structure of the headbox can be altered slightly so that under such operating conditions the depth of the horizontal channel 15 will be reduced to that of the flowing stock so that the entire channel is filled with stock. In this case the level of the stock will remain constant within the channel 15 since the channel is kept filled and the use of the bleeder pipe may not be required.

Thus it will be seen that this invention provides novel apparatus and method for so physically conditioning a flowing stream of stock that "frozen flow" conditions are reached prior to and are effective at the moment at which the stock is projected through the slice.

It is, of course, to be understood that various details of arrangements and proportions of parts may be modified within the scope of the appended claims.

I claim:

1. Apparatus of the character described including a flow channel of rectangular cross-section having a stock-receiving inlet chamber, an upwardly slanting portion extending from said inlet chamber and a horizontal portion extending from said upwardly shanting portion, said upwardly slanting portion being provided with a plurality of tiers of small diameter flow-modifying pipes disposed with their axes parallel to the longitudinal axis of said upwardly slanting portion, and means for filling the voids between the exteriors of said pipes whereby to force all stock leaving said inlet chamber to pass through said pipes.

2. Apparatus of the character described including a flow channel of rectangular cross-section having a stock-receiving inlet chamber, an upwardly slanting portion extending from said inlet chamber and a horizontal portion extending from said upwardly slanting portion, said upwardly slanting portion being provided with a plurality of tiers of small diameter flow-modifying pipes disposed with their axes parallel to the longitudinal axis of said upwardly slanting portion, means for filling the voids between the exteriors of said pipes whereby to force all stock leaving said inlet chamber to pass through said pipes, an orifice plate secured within each of said pipes adjacent the intake end thereof, and an adjustable slice mounted at the discharge end of said horizontal portion.

3. Apparatus of the character described including a flow channel of rectangular cross-section having a stock-receiving inlet chamber, an upwardly slanting portion extending from said inlet chamber and a horizontal portion extending from said upwardly slanting portion, said upwardly slanting portion being provided with a plurality of tiers of small diameter flow-modifying pipes disposed with their axes parallel to the longitudinal axis of said upwardly slanting portion, means for filling the voids between the exteriors of said pipes whereby to force all stock leaving said inlet chamber to pass through said pipes, an orifice plate secured within each of said pipes adjacent the intake end thereof, an adjustable slice mounted at the discharge end of said horizontal portion, and means for supplying stock to said inlet chamber.

4. Apparatus of the character described including a flow channel of rectangular cross-section having a stock-receiving inlet chamber, an upwardly slanting portion extending from said inlet chamber and a horizontal portion extending from said upwardly slanting portion, said upwardly slanting portion being provided with a plurality of tiers of small diameter flow-modifying pipes disposed with their axes parallel to the longitudinal axis of said upwardly slanting portion, means for filling the voids between the exteriors of said pipes whereby to force all stock leaving said inlet chamber to pass through said pipes, an orifice plate secured within each of said pipes adjacent the intake end thereof, an adjustable slice mounted at the discharge end of said horizontal portion, and means for supplying stock to said inlet chamber, said last named means including a relatively large diameter main stock supply pipe, a transversely disposed header connected to said stock supply pipe and having a diameter somewhat less than that of the supply pipe, and a plurality of pipes connecting said header with said inlet chamber.

5. Apparatus of the character described including a flow channel of rectangular cross-section having a stock-receiving inlet chamber, an upwardly slanting portion extending from said inlet chamber and a horizontal portion extending from said upwardly slanting portion, said upwardly slanting portion being provided with a plurality

of tiers of small diameter flow-modifying pipes disposed with their axes parallel to the longitudinal axis of said upwardly slanting portion, means for filling the voids between the exteriors of said pipes whereby to force all stock leaving said inlet chamber to pass through said pipes, an orifice plate secured within each of said pipes adjacent the intake end thereof, an adjustable slice mounted at the discharge end of said horizontal portion, and means for supplying stock to said inlet chamber, said last named means including a relatively large diameter main stock supply pipe, a transversely disposed header connected to said stock supply pipe and having a diameter somewhat less than that of the supply pipe, and a plurality of pipes connecting said header with said inlet chamber, each of said last named pipes having an orifice plate secured therein.

6. Headbox apparatus for papermaking machines comprising a pipe for supplying stock under conditions of turbulent flow, a header connected with said supply pipe for receiving and adjusting the flow velocity of said stock, a plurality of discharge pipes extending from said header for further adjusting the flow velocity of said stock and being connected with the intake end of a flow box, said intake end of the flow box being provided with a chamber and a plurality of tiers of pipes extending upwardly therefrom in parallel aligned relationship for further adjusting the velocity of said stock, the intake end of each of the pipes in said tiers being provided with a stock-accelerating orifice, said flow box including an extended horizontal channel for receiving stock from said last-named pipes and for effecting conversion of the flow characteristics of said stock from a turbulent condition to a "frozen flow" condition, and a slice connected to said horizontal channel for projecting the "frozen flow" stock onto the wire of an associated papermaking machine.

7. Headbox apparatus for papermaking machines comprising a pipe for supplying stock under conditions of turbulent flow, a header connected with said supply pipe for receiving and adjusting the flow velocity of said stock, a plurality of discharge pipes extending from said header for further adjusting the flow velocity of said stock and being connected with the intake end of a flow box, the intake end of said flow box being provided with a chamber and a plurality of tiers of pipes extending therefrom in parallel aligned relationship for further adjusting the velocity of said stock, said flow box including an extended horizontal channel for receiving stock from said last-named pipes and for effecting conversion of the flow characteristics of said stock from a turbulent condition to a "frozen flow" condition, means for supplying compressed air to said horizontal channel to maintain pressure on the stock flowing therethrough, and a slice connected to said horizontal channel for projecting the "frozen flow" stock onto the wire of an associated papermaking machine.

8. Apparatus of the character described including a flow channel of rectangular cross-section having a stock-receiving inlet chamber, an upwardly extending portion projecting from said inlet chamber and comprising a plurality of flow-modifying pipes arranged in multi-layer parallel relationship, the free ends of said pipes extending into open communication with one end of an extended horizontal portion, an orifice plate being attached to each of said pipes adjacent the intake end thereof, and an adjustable slice mounted at the discharge end of said horizontal portion.

9. Headbox apparatus for papermaking machines comprising a pipe for supplying stock under conditions of turbulent flow, a header connected with said supply pipe for receiving and adjusting the flow velocity of said stock, a plurality of orifice-containing discharge pipes extending from said header for accelerating and decelerating said stock and being connected with the intake end of a flow box, the intake end of said flow box being provided with a chamber of rectangular cross section extending across the full width thereof, means for further accelerating and decelerating said stock comprising upwardly extending multi-layered closely spaced parallel-aligned conduits each defining a passageway having a length several times greater than the maximum cross-sectional diameter of said conduit and an orifice plate attached to each of said conduits adjacent the intake end thereof, the other ends of said conduits entering into open communication with an extended horizontal channel, and a slice connected to the discharge end of said horizontal channel for projecting said stock onto the wire of an associated papermaking machine.

10. Apparatus of the character described including a flow channel of rectangular cross-section having a stock-receiving inlet chamber, an upwardly slanting portion extending from said inlet chamber and a horizontal portion extending from said upwardly slanting portion, said upwardly slanting portion being provided with a plurality of tiers of small diameter flow-modifying pipes disposed with their axes parallel to the longitudinal axis of said upwardly slanting portion, said small diameter flow-modifying pipes being so constructed and arranged that no stock is admitted into the voids between the exteriors thereof, an orifice plate secured within each of said pipes adjacent the intake end thereof, an adjustable slice mounted at the discharge end of said horizontal portion, and means for supplying stock to said inlet chamber, said last named means including a relatively large diameter main stock supply pipe, a transversely disposed header connected to said stock supply pipe and having a diameter somewhat less than that of the supply pipe, and a plurality of orifice-containing pipes connecting said header with said inlet chamber.

References Cited in the file of this patent

UNITED STATES PATENTS

851,227	Eibel	Apr. 23, 1907
1,610,742	Bucking	Dec. 15, 1926
1,890,634	Wenzel	Dec. 13, 1932
1,909,150	Bell-Irving et al.	May 16, 1933
2,156,445	Baxter	May 2, 1939
2,186,761	Malkin	Jan. 9, 1940
2,205,693	Milne	June 25, 1940
2,225,435	Kellett et al.	Dec. 17, 1940
2,347,130	Seaborne et al.	Apr. 18, 1944
2,509,822	Hornbostel	May 30, 1950

OTHER REFERENCES

Gough: Pulp and Paper Magazine of Canada, April 1936, pages 259–262. (Copy in Divn. 67.)

Moss et al.: Tech. Assn. Papers, Series 21, 1938, pages 250 to 261. (Copy in Divn. 56.)

Bratton et al.: Paper Trade Journal, October 1, 1942, pages 112–115. (Copy in Divn. 67.)

Gray et al.: Technical Association Papers, Series 27, 1944, pages 309 to 314. (Copy in Divn. 56.)