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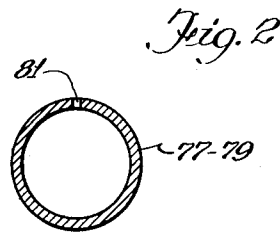
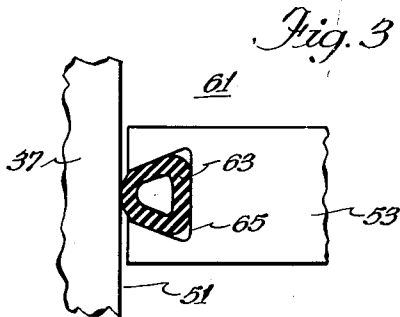
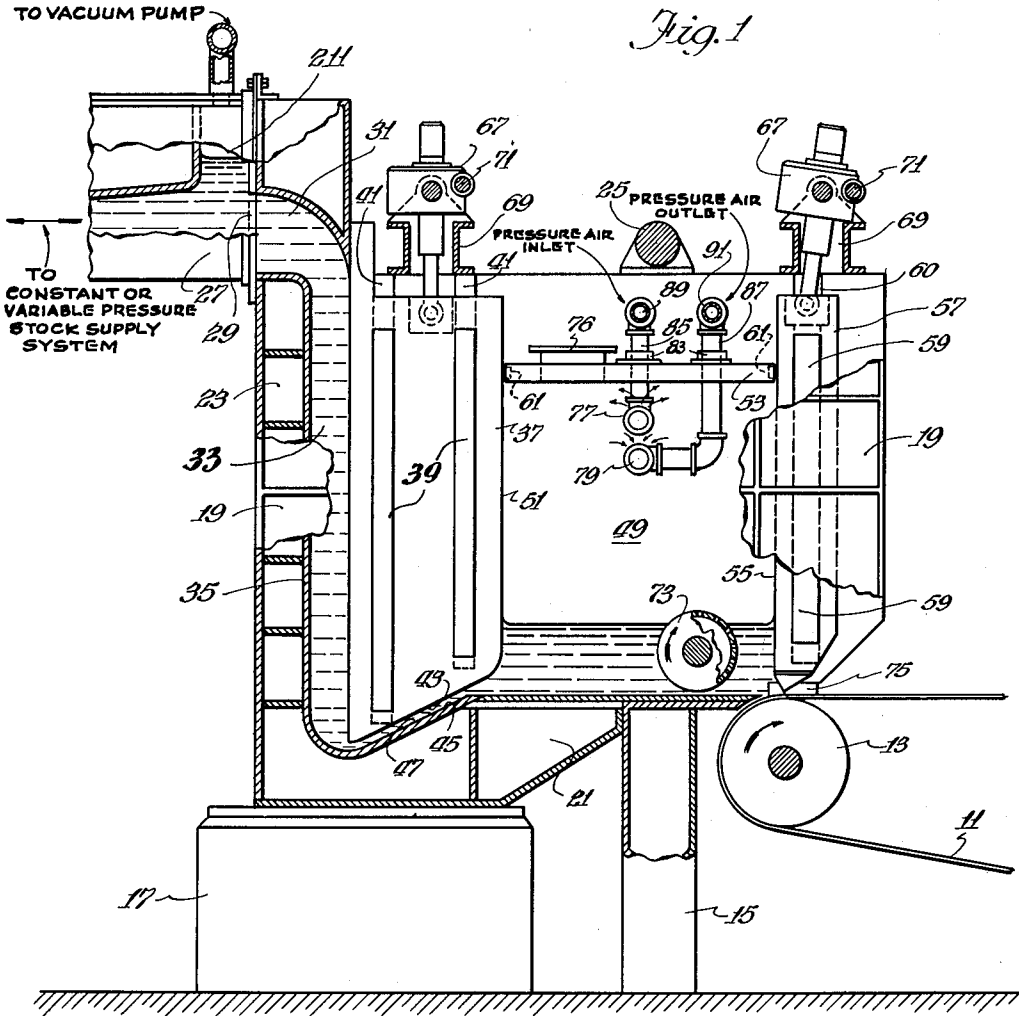
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PAPERMAKING MACHINE

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5 Sheets-Sheet 1



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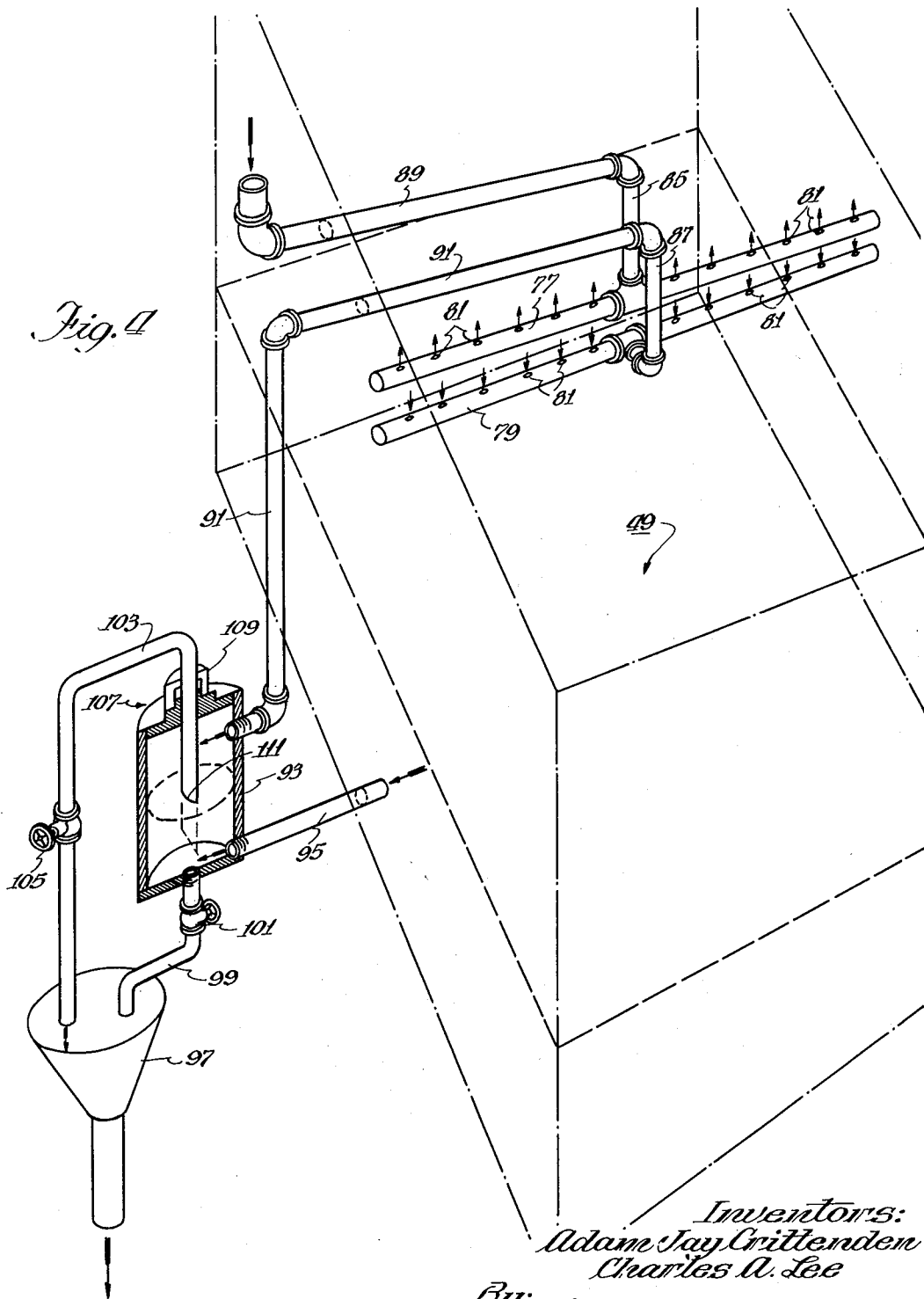
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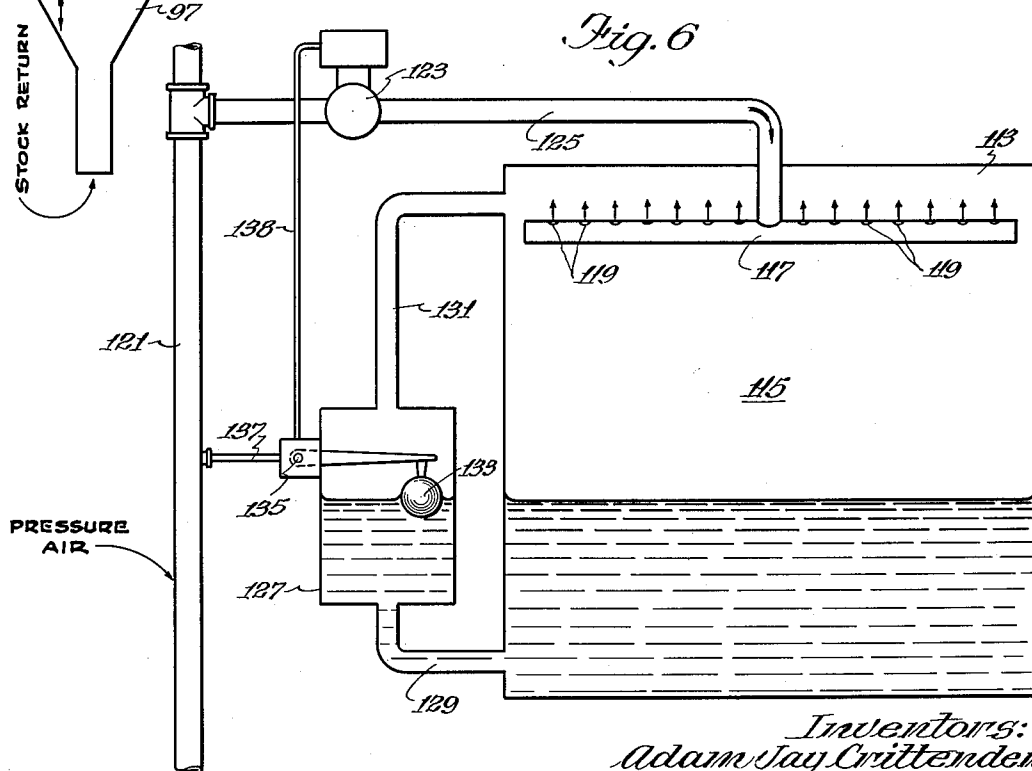
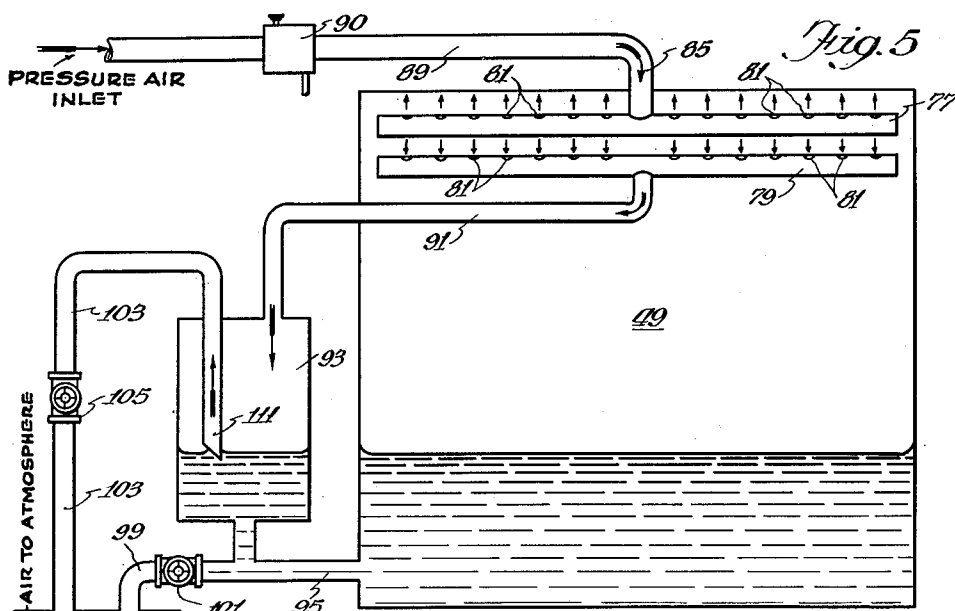
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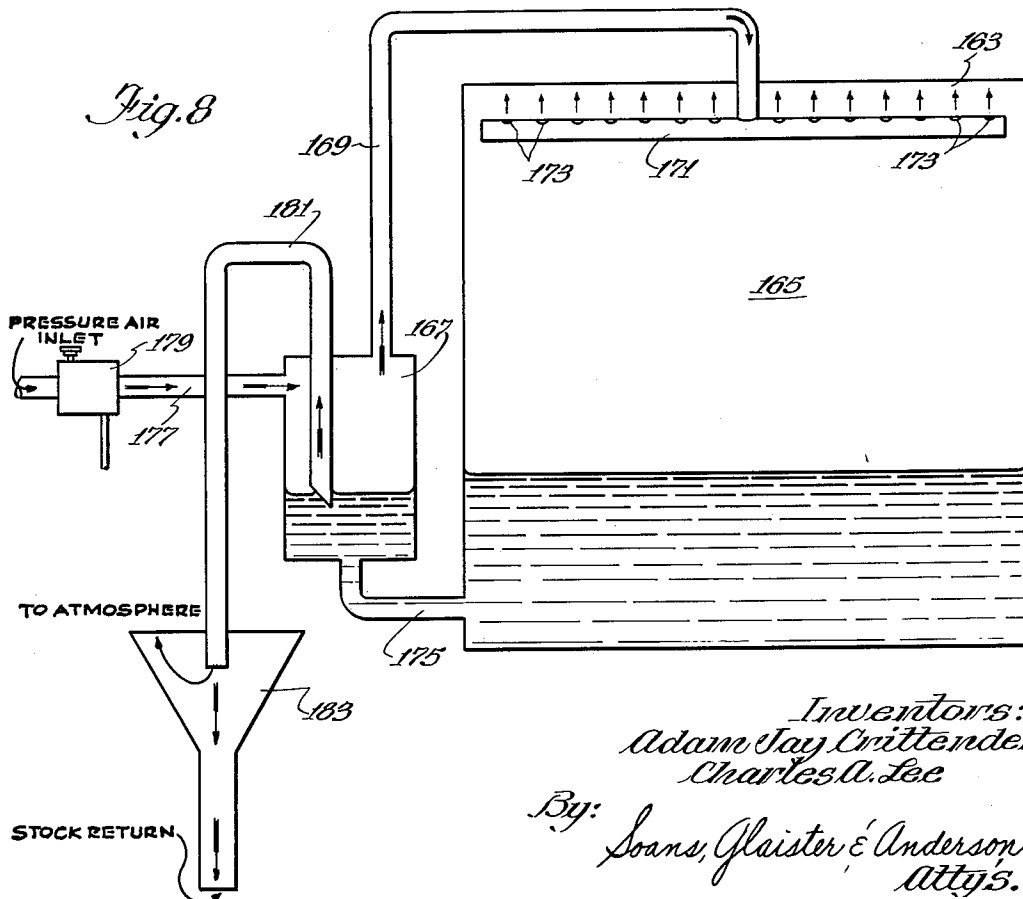
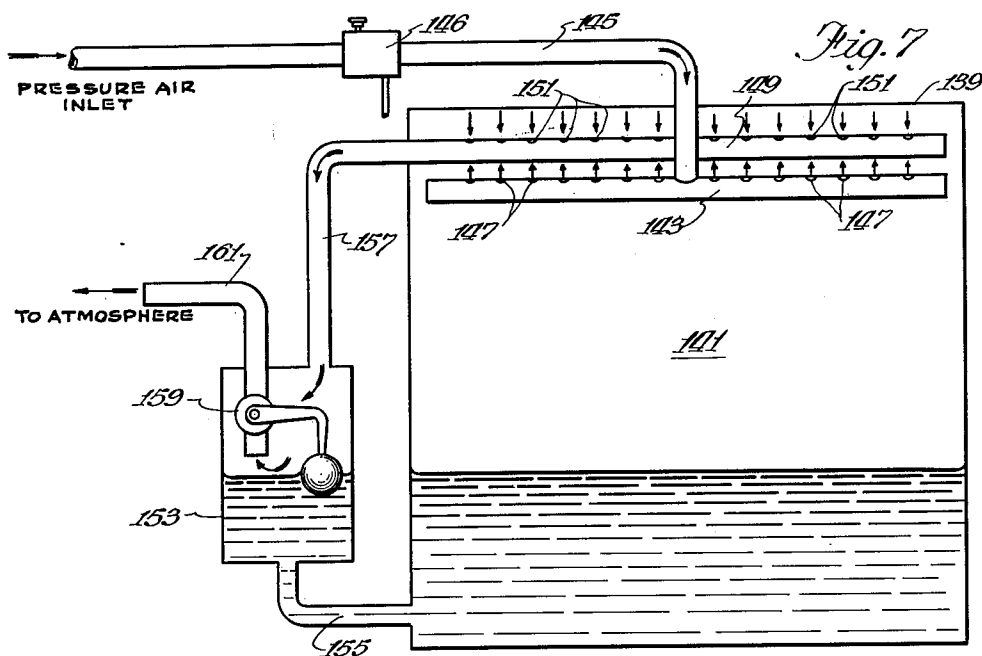
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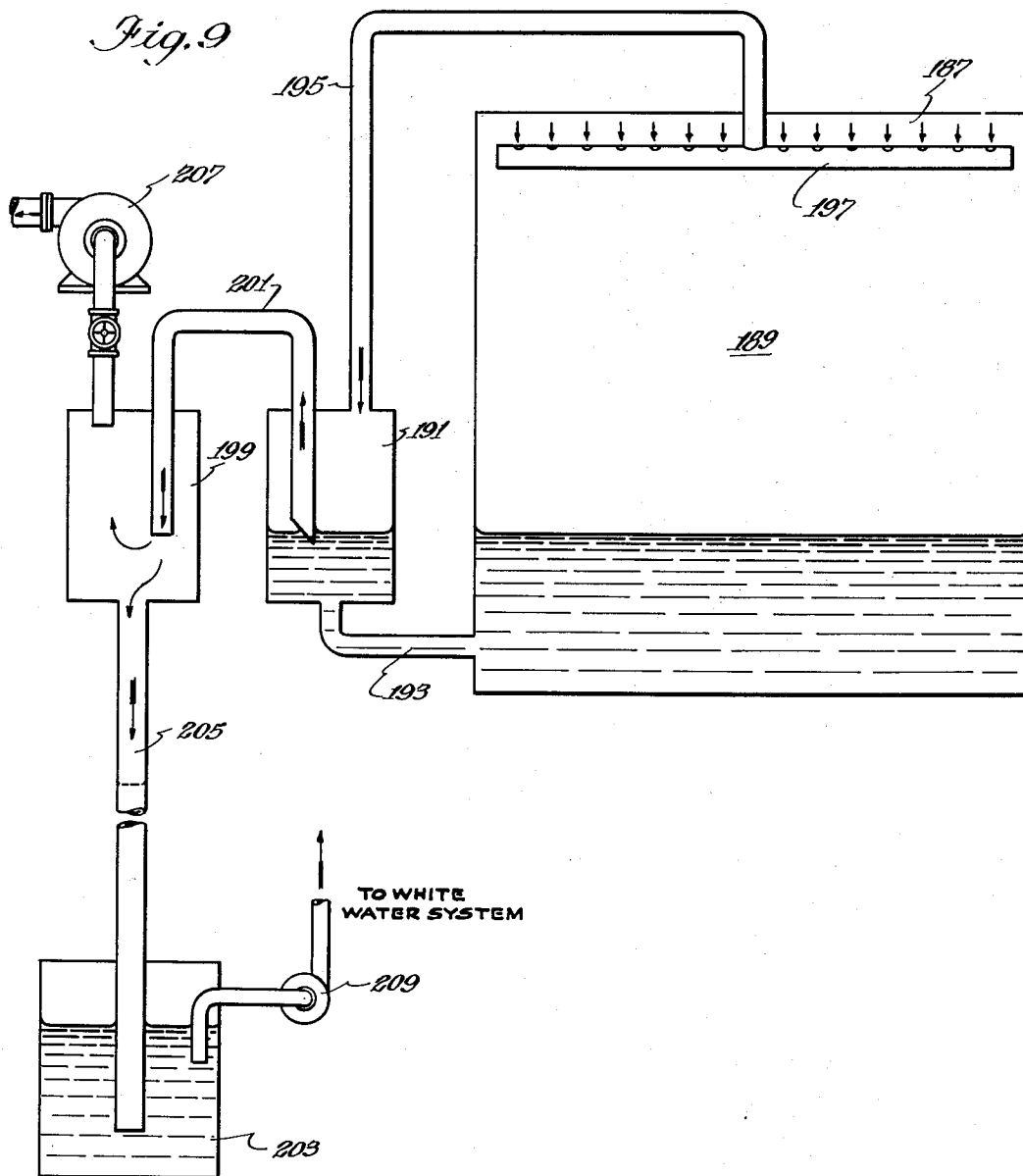
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5 Sheets-Sheet 5



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PAPERMAKING MACHINE

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19 Claims. (Cl. 92—44)

The present invention relates to papermaking machinery, and especially to the construction and operation of papermaking headbox and inlet mechanisms wherein the stock is maintained at a predetermined pressure or level, or both. In this connection, the term "stock" as used herein will be understood to refer to the dilute, aqueous suspension of papermaking fiber, with or without additional papermaking materials, which is delivered as a flowing stream of fluid to the web-forming region of a papermaking machine by way of the headbox, inlet or other stock delivery mechanism.

In the manufacture of a given weight paper on a particular machine, it will usually be found that there is an optimum depth for the flowing stream of stock which is contained within a headbox or other inlet mechanism, and this depth is, in general, independent of the speed of operation of the machine. At the same time, in order to attain satisfactory machine operation, it is necessary to supply the stock to the web-forming region of the machine at a pressure which is capable of producing a spouting velocity at the slice, or equivalent means defining the downstream edge of the web-forming region, approximately equal to the velocity of the forming wire. The two requirements are inherently conflicting and are incapable of correlation except at some one range of operating speeds, which is usually at very low wire speed. As a result, the operation of most papermaking machines, and especially headbox type machines, has been conducted under compromise conditions. Specifically, in order to obtain sufficient head to produce a spouting velocity at the slice that is adequate for satisfactory operation, it has been necessary to utilize headbox constructions wherein the stock has been maintained at a depth far greater than that which would produce the optimum results insofar as the quality of the paper is concerned.

In an effort to avoid some of these difficulties, it has been proposed to use what is sometimes spoken of as a pressurized headbox construction. In arrangements of this type, the stock is supplied to an enclosed ponding or headbox chamber, from which it is discharged onto the wire. The upper portion of the ponding chamber is connected to a source of pressure air, and during operation, a body or pad of air, under pressure, is maintained in the upper portion of the ponding chamber. This has the effect of reducing the level of the stock within the ponding chamber, while maintaining sufficient pressure to secure adequate spouting velocity at the slice. However, the apparatus does not include any means for maintaining the level of the stock in the ponding chamber at any particular value, and because of this and certain other inherent features, the apparatus tends to be unstable in operation and is subject to certain other difficulties.

Subsequent to this initial arrangement, pressurized headbox apparatus was developed which included a vent in the side wall of the headbox, arranged to maintain automatically the level of the stock within the headbox or inlet chamber at a predetermined value. This arrangement has also proved subject to certain important opera-

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tional disabilities, particularly when it is being used in connection with papermaking machinery wherein it is desired to maintain the level of the stock within the headbox or equivalent chamber at a value less than about 18 inches. In such instances, the wall vent level regulating mechanism produces conditions of instability in the region of the slice, which conditions are evidenced, in part, by the formation at the slice of irregularities in the flow pattern having the general shape of fishtails. These irregularities of flow have proven almost impossible to control, and since they lower materially the quality of the paper produced, their avoidance is greatly to be desired.

Thus, while the present invention is directed to the same general problem as these earlier structures, that is, the provision of a headbox or equivalent type papermaking machine wherein the liquid level in the headbox chamber can be controlled independently of the pressure maintained within that chamber, the principal object of the present invention is the elimination of the transient instabilities and other operational difficulties which are inherent in the previously known pressurized headbox constructions.

In the attainment of this object, the level regulating means of the invention provides for introducing air, or an equivalent gas, which may be under pressure, into a headbox chamber and for removing air and stock from that chamber under such conditions that no surface or sub-surface disturbances are set up in the stock contained within the headbox chamber. As will appear, the invention thereby makes possible the maintaining of the stock at a predetermined depth within the headbox chamber, independently of the pressure conditions within that chamber, while at the same time eliminating the difficulties inherent in the previously known arrangements.

The invention finds its most important immediate use in connection with headbox type Fourdrinier papermaking machines, and will be described in conjunction with such a machine. It will be understood, however, that the principles of the invention are applicable to other types of apparatus.

In the drawings, wherein certain representative embodiments of the invention are illustrated:

Figure 1 is a side elevational view, partially in section, of the headbox and certain of adjacent structure at the wet end of a headbox type, Fourdrinier papermaking machine;

Figure 2 is a sectional view of one of the air inlet and air outlet tubes, constituting a part of the apparatus illustrated in Figure 1;

Figure 3 is a fragmentary, sectional view illustrating a portion of a seal mechanism embodied in the apparatus illustrated in Figure 1;

Figures 4 and 5 are, respectively, isometric and schematic views, showing the general arrangement of the level and pressure control mechanism embodied in the structure shown in Figure 1; and

Figures 6 to 9 are schematic views, similar to Figure 5, illustrating other stock level and pressure control mechanisms in accordance with the principles of the present invention.

As previously pointed out, the pressure and level-regulating mechanism of the present invention is operable to maintain within a headbox or equivalent stock delivery mechanism, a predetermined level of stock, which level is maintained independently of the total pressure head (or spouting velocity) of the stock. Further, this level is maintained independently of the total volume of stock which is passing through the headbox chamber, and the control is accomplished under such conditions and in such manner that there is substantially no disturbance at the surface or below the surface of the body of stock

passing through the headbox chamber during the operation of the control mechanism.

The particular headbox structures illustrated in the drawings are intended especially for use in conjunction with Fourdrinier type machines, and in Figure 1 a breast roll and a Fourdrinier wire of conventional design are illustrated at 11 and 13. It will be understood that the machine will also include the usual stock supply system, white water system, deckles for confining the stock on the wire, suction boxes, presses, felts, driers, and the other additional apparatus which is required in the manufacture of paper, the apparatus shown in Kellett Patent No. 2,134,408 being illustrative of such arrangements. The breast roll 13 will desirably be supported in such manner that its position relative to the headbox can be accurately adjusted. This may be accomplished by the use of an automatically operable, adjustable roll support of a hydraulic or other type, these mechanisms being commercially available.

The defining walls of the headbox structure are fabricated of suitable angle, beam and plate sections, conveniently by welding, and the entire headbox is supported in cooperative relation to the wire, breast roll and other machine elements by means of suitable steel and concrete pillars, as illustrated at 15 and 17. Essentially, the headbox comprises two, rigid, vertically extending side elements 19, commonly designated "pond sides," which are fastened to each other by a suitable bottom section 21 and an end wall 23, which extends across the stock inflow end of the headbox.

To further strengthen the structure, the upper end of the pond sides 19 are connected by a stiffening member 25 which is circular in cross-section. Stock is delivered to the headbox at a predetermined pressure by means of a conduit 27 which leads to a suitable source of stock at a predetermined pressure, for example, the discharge end of a series of screens or a suitable constant pressure pump, not shown. The discharge end 29 of the stock delivery conduit 27 in the illustrated structure is rectangular in outline and is adapted to connect with the inflow end 31 of a flow spreading conduit 33 which is adapted to widen the relatively narrow stream of stock delivered by the stock supply means to the full width of the machine.

The upstream vertical surface of the flow spreading conduit 33 is defined by a plate member 35 which extends transversely across the machine. The downstream surface of the flow spreading conduit 33 is defined by one surface of a vertically adjustable, throttling slice 37. The throttling slice 37 is a hollow, completely enclosed, fabricated, box-like structure which extends across the full width of the machine and is supported for limited vertical movement relative to the pond sides 19 by means of suitable guide members 39, which engage guide slots 41 formed in those sides.

The lower surface 43 of the throttling slice 37 cooperates with the adjacent surface 45 of the headbox bottom 21 to define a generally wedge-shaped passageway 47 of uniform cross-sectional outline and of uniformly increasing cross-sectional area in the downstream direction, across the entire width of the machine. The passageway 47 serves to conduct the stock, which is delivered to the headbox at predetermined pressure, into the ponding chamber 49 within the headbox proper.

The defining walls of the ponding chamber 49, which receives and holds momentarily the stock flowing into and through the headbox, are defined by the sides 19 and bottom 21 of the headbox, the downstream surface 51 of the throttling slice 37, a top or cover unit 53, and the upstream surface 55 of the discharge or wire slice 57. The wire slice 57, similar to the throttling slice 37, constitutes a hollow, fabricated, box-like structure which is supported for limited vertical movement within the headbox by means of suitable projecting guides 59 which engage guide slots 60 in the pond sides 19.

The cover unit 53 is likewise of fabricated construction, and extends between the two pond sides 19 in the position shown in the drawings. In order that the throttling and wire slices 37 and 57 may be adjusted during operation of the machine, it is desirable that the mechanism include yieldable sealing means 61 between the fore-and-aft edges of the cover unit, and the adjacent slice surfaces 51 and 55. This sealing means may conveniently comprise an O-ring type seal, constituting, as shown in Figure 3, a resilient sealing tube 63, which is disposed within an under-cut slot 65. The tube 63 may or may not be under internal pressure.

To provide for convenient adjustment of the slice mechanisms, a pair of spaced-apart, power-operated lift units 67 are connected to each of the slice structures 37 and 57. The units 67 are supported upon suitable transversely-extending beam sections 69, and the two units operating each of the slices are desirably interconnected, as by the shaft indicated at 71, in order to assure simultaneous operation of the lift units associated with each slice.

One or more power driven, rotatable distributor rolls, as illustrated at 73, may be provided within the ponding chamber 49, and it is desirable that all such rolls shall be adjustably supported, in order that the position of the rolls within the ponding chamber 49 can be adjusted to produce optimum operating conditions. The headbox structure also includes suitable seals 75 at either side of the ponding chamber 49 for engaging the surface of the wire in the region of the wire slice 57.

The cover unit 53 for the ponding chamber, which unit co-acts with the other elements of the headbox structure to completely enclose that chamber, except for the stock inflow opening 47 and the stock outflow opening provided beneath the lower edge of the wire slice 57 and the adjacent surface of the wire 11, may be provided with one or more covered access openings, as indicated generally at 76. The cover unit 53 also serves as the support for certain of the elements of the air inflow and air outflow mechanisms constituting a part of the depth and pressure control mechanism embodied in the apparatus.

The complete control mechanism is illustrated in Figures 4 and 5, and as there shown, it includes a horizontally extending air inflow tube 77 and a horizontally extending air outflow tube 79. In order to minimize air disturbance within the ponding chamber 49 during operation of the control mechanism, the air inflow tube 77 and the air outflow tube 79 both comprise a closed conduit having a plurality of spaced orifices in the upper surface thereof, as indicated at 81, and the tubes are arranged in close proximity to each other in the upper portion of the ponding chamber. The tubes 77 and 79 thus accomplish an air diffusion function, and this, in combination with the close spacing and positioning of the tubes effectively prevents any disturbance of the surface of the stock within the ponding chamber as a result of the flow of air into and out of that chamber.

The air inflow and air outflow tubes 77 and 79 are supported upon the cover unit 53 of the ponding chamber by means of suitable flanged connections 83 (Fig. 1) which engage vertically extending pipes 85 and 87, one of which is connected to the central portion of one of the tubes, as shown. The pipe 85 connected to the air inflow tube 77 is, in turn, connected by additional piping to a source of pressure air. The source of pressure air is desirably of a constant pressure type or the line 89 may include an adjustable pressure regulating unit, as indicated at 90. The support pipe 87 for the air outflow tube 79 is connected by other piping 91 to the upper end of a cylindrically shaped, auxiliary tank or receiver 93, which is supported adjacent one of the pond sides 19 with the bottom of the tank adjacent the bottom of the ponding chamber 49.

The auxiliary tank or receiver 93 should have a vertical dimension which is greater than the depth of liquid

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which is to be maintained within the ponding chamber 49. The lower end of the receiver 93 is connected to the interior of the ponding chamber 49 by a pipe or conduit 95, and for drain and clean-out purposes, the bottom of the receiver 93 is adapted to be connected to a stock return 97 via a conduit 99 which is provided with a shut-off valve 101, as shown.

Extending through the upper defining wall of the receiver 93 is a combination air and liquid discharge line 103 which is also adapted to empty into the stock return 97, and which may also be provided with a shut-off valve, as shown at 105. The discharge line 103 passes into the receiver 93 by way of a sliding gland connection 107, which includes a screw-on gland fitting 109, and by means of which it is possible to raise or lower the discharge tube relative to the receiver. The inlet end 111 of the discharge line 103 is desirably cut at an angle in order to facilitate the simultaneous discharge of air and liquid therethrough, as will be hereinafter described.

The apparatus illustrated in Figures 1 and 4, and the diagrammatic view, Figure 5, is operable to maintain the stock within the ponding chamber 49 at a predetermined level which is independent of the pressure at which the stock is maintained. It may also be used to maintain the stock at a predetermined pressure as well as a predetermined level, although under normal operation, the stock pressure will be determined by the pressure at which the stock is delivered to the ponding chamber 49. The stock pressure may, therefore, be regulated to any predetermined value by adjustment of the stock supply pressure in the stock delivery conduit 27 and, to a lesser extent, by adjustment of the throttling slice 37. More specifically, the operation of the apparatus is as follows:

Stock reaches the interior of the ponding chamber 49 via the flow spreading conduit 33 and the passageway 47 at a predetermined pressure. The level at which the stock is maintained within the ponding chamber 47 is controlled by the position of the inflow end 111 of the stock and air discharge line 103, and by virtue of the adjustable support for that line, provided by the gland connection 107, the stock level can be adjusted to any predetermined value within the dimensional limits of the receiver chamber. Air is supplied to the enclosed ponding chamber 49, through the air inflow pipe 89 and the air inflow tube 77, at a pressure which should be at least somewhat greater than the pressure at which the stock is delivered to the ponding chamber. This air is free to flow outwardly from the air inflow tube 77 into the interior of the ponding chamber 49. By virtue of the use of the spaced-apart air discharge openings 81 in the inflow tube 77, which openings are arranged to discharge upwardly against the cover element 53 for the ponding chamber, the air inflow into that chamber will be well diffused and will not produce flow disturbances at the surface of the stock flowing through the ponding chamber.

Pressure air may also flow out of the ponding chamber 49 and into the receiver 93 by way of the outflow tube 79 and the pipe 91. Stock is free to flow into the receiver 93 through the conduit 95, the valve 101 being normally closed. The valve 105 in the discharge line 103 is normally open, and hence, that line is available to discharge air or stock or both from the receiver chamber into the stock return and air vent 97.

When the level of the stock within the ponding chamber 49 is at the predetermined height, a condition of balance will exist. Sufficient pressure air will flow into the ponding chamber 49 to balance leakage and to provide at least a small excess which is discharged through the air outflow tube 79. There will also be some flow of stock from the ponding chamber into the receiver via the conduit 95, since under balance conditions, there is desirably a small continuous discharge of both stock and air from within the receiver 93 via the discharge line 103.

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If the level of the stock within the ponding chamber 49 drops below the level at which it is to be maintained, the stock level within the receiver 93 will also drop. This will result in an increase in the area of the opening at the inlet end of the discharge line 103, through which air can be vented from the receiver, and air will be discharged at an increasing rate through the discharge line 103. At the same time, the rate at which stock is being discharged will decrease. The increased discharge of air will result in a lowering of the pressure within the ponding chamber 49, and that will be accompanied by a rise in the level of the stock within that chamber. As the stock level rises, it will progressively close-off the opening into the discharge line 103, and in a very short interval, a balance will be reached, at which time some air and some stock will again be discharged simultaneously through the discharge conduit.

If the stock level rises above the selected value, the operation will be substantially reversed. The rising stock will reduce or completely shut-off the normal flow of pressure air out of the receiver 93. That will cause the pressure within the ponding chamber to increase with resulting lowering of the stock level to the determined operating level.

The apparatus is operable to maintain the level of stock within very close limits. At the same time, by virtue of the manner in which the air pressure is introduced into the ponding chamber and the manner in which stock and air are discharged from that chamber, there is substantially no tendency for surface or sub-surface disturbance of the body of stock which is contained within the ponding chamber. The mechanism is simple and entirely fool-proof in its operation, and it completely eliminates the difficulties which are inherent in the prior pressure and level regulating mechanisms.

As previously stated, the invention may be carried out by the use of a number of different types of apparatus, and various other control arrangements in accordance with the invention are illustrated in Figures 6 through 9 inclusive. In all of these arrangements, however, provision is made for maintaining control of the pressure and level within the ponding or other flow chamber without disturbing the surface of the body of stock within that chamber, and without setting-up undesirable sub-surface flow currents therein.

It is generally impractical to effect the complete sealing of a headbox structure, and accordingly, it is possible to operate mechanisms in accordance with the invention without providing a specific air discharge mechanism. In other words, the leakage within a headbox structure is relied upon to furnish an adequate air discharge means. An arrangement operating in this manner is shown in the diagrammatic view of Figure 6. In that view, a headbox or equivalent stock delivery mechanism is illustrated at 113. The headbox structure defines the walls of a ponding chamber 115, which is closed except for stock inlet and stock outlet openings, and the usual leakage openings.

An air inflow diffuser tube 117, similar to the air inlet tube 77 of the apparatus illustrated in Figures 1-5 is shown in position to discharge air upwardly through spaced discharge orifices 119 into the upper portion of the ponding chamber 115. The diffuser tube 117 is, in turn, connected to a source of pressure air, such as the line 121, by way of an air-operated throttling valve 123 and suitable piping 125. An auxiliary control tank or receiver 127 is connected at its lower end to the ponding chamber 115, below the level of the stock contained therein, by a conduit 129. The upper end of the receiver 127 is connected to the ponding chamber 115, above the level of the stock contained therein by a similar conduit 131. Disposed within the receiver is a float 133, which is arranged to operate an adjustable pilot valve 135, supported on the defining walls of the receiver. The pilot valve 135, in turn, is operable to control the

delivery of air to the air-operated throttling valve 123 by way of pressure lines 137 and 138.

The pilot valve 135 is capable of being adjusted with reference to the throttling valve 123 so that the amount of pressure air being delivered to the ponding chamber 115 through the inflow diffuser 117 will be controlled in response to the level of the stock in the receiver or auxiliary control chamber 127, which level is responsive to the level in the ponding chamber 115. It is possible, by this arrangement, to admit just sufficient air to balance the amount of leakage within the ponding chamber 115, and thereby to maintain the stock at a predetermined level while under a pressure head which is independent of the actual depth of the stock. The pressure head is necessarily determined primarily by the pressure at which the stock is delivered to the ponding chamber 115, but this is readily capable of adjustment to any required value by control of the stock delivery pump or other mechanism.

In the operation of apparatus of this type, it is generally advantageous to deliver air to the throttling valve structure at a pressure which is not greatly in excess of the maximum pressure which is to be maintained within the headbox ponding chamber. However, the use of a suitably designed throttling valve makes possible satisfactory operation, even in instances where the pressure is substantially different or where the supply pressure may vary during the operating cycle.

In all instances, however, the operation will follow essentially the same pattern. After adjustment of the pilot and throttling valves 135 and 123 to effect admission of pressure air to the ponding chamber 115 at a suitable, predetermined pressure, the float 133 is adjusted to effect operation of the pilot valve when the stock level goes above or below the level at which the stock is to be maintained within the ponding chamber.

Under stable operation, the amount of air admitted to the ponding chamber will exactly balance leakage losses, and the liquid level will remain constant. If the stock delivery pressure should decrease, because the machine is being slowed down or for any other reason, the stock level will drop. The pilot and throttling valves will then operate to restrict the delivery of pressure air to the ponding chamber, and after a short interval, leakage from the headbox will restore the proper pressure relationships and the stock level will return to the proper operating value. Similarly, if the stock level rises, pressure air will be admitted to the ponding chamber at an increased rate until the stock level drops to the proper value and equilibrium is again reached.

It is also possible to accomplish control of the liquid level by controlling the rate at which pressure air is discharged from the headbox and this arrangement, an example of which is shown in Figure 7, is sometimes preferable to the arrangement shown in Figure 6. The structure illustrated in Figure 7 includes a headbox 139, which defines the walls of a ponding chamber 141 that is closed except for stock inflow and stock outflow openings. As in the previously described structures, an air inflow diffuser conduit 143 is disposed within the ponding chamber 141 adjacent the upper wall thereof, and this conduit is connected to a source of supply of pressure air by suitable piping 145. As in the Figure 5 arrangement, the line 145 may include an adjustable pressure regulator, indicated at 146, to assure the delivery of air at a constant pressure. The diffuser conduit 143 includes spaced orifice openings 147, whereby air is admitted to the interior of the headbox ponding chamber under such conditions that disturbance of the surface of the stock contained within that chamber is avoided.

The apparatus also includes air outlet means, consisting of a tube or conduit 149 disposed above the air inflow 143 and provided with spaced openings or perforations 151 in the upper surface thereof. An auxiliary control chamber or receiver 153, similar to the auxiliary control receivers 93 and 127 in the previously described structure,

is connected at its lower end to the ponding chamber 141, below the level of the stock contained within that chamber by a conduit 155. The upper end of the receiver 153 is connected directly to the air outflow pipe 151 in the upper portion of the ponding chamber by a line 157. Within the receiver 153, there is provided a float operated throttling valve 159 which is connected into an air discharge line 161 extending through the upper defining wall of the receiver.

In the operation of this mechanism, the rate at which air is vented to the atmosphere from the auxiliary control chamber provided within the receiver 153 is determined by operation of the float controlled throttling valve 159. As in the other structures, the pressure at which the stock is maintained within the ponding chamber 141 is determined primarily by the pressure at which the stock is delivered to that chamber, and the stock level is determined by adjustment of the operating position of the float valve 159. The pressure air should be supplied at a pressure which is above the pressure to be maintained within the ponding chamber, and at a rate which is in excess of the normal rate of leakage.

During normal operation, the adjustment of the throttling valve 159 will be such that the rate of air discharge through the line 161, when the stock level is at the predetermined value, will just balance the rate at which the excess air reaches the receiver through the line 157. The pressure within the headbox will then be equal to the stock pressure and equilibrium conditions will exist. In the event that the level of the stock within the ponding chamber drops below the predetermined value, the throttling valve 159 will open to increase the rate of discharge of air through the discharge line. This will lower the pressure of the air pad within the ponding chamber 141, whereupon the liquid level will rise. If the stock level within the ponding chamber 141 rises above the pre-selected value, the float valve will then operate to reduce the rate of air discharge. Increased pressure will be produced within the ponding chamber, the liquid level will drop, and a balance will be restored.

In the arrangements heretofore described, the pressure air which has been admitted to the interior of the ponding chamber has been supplied through a line which is separate from the connections to the auxiliary or control chamber. It is possible to operate equipment in accordance with the invention by the use of only two connections to the interior of the ponding chamber, one above and one below the stock level, and an arrangement of this type is shown in Figure 8. In the Figure 8 structure, the walls of the headbox are indicated at 163 and the ponding chamber within the headbox at 165. The headbox 163 similar to the headbox of the Figure 1 structure, includes stock inflow and stock outflow openings located below the stock level and is otherwise closed. An auxiliary control chamber is illustrated at 167, and as shown, the upper end of that chamber is connected by a conduit 169 directly to a diffusion type air inflow conduit, which consists of a pipe 171 provided with spaced openings 173 in the upper surface thereof, and which is disposed in the upper portion of the headbox ponding chamber 165. The lower end of the auxiliary chamber 167 is connected to the ponding chamber 165 below the stock level therein by a second conduit 175.

Pressure air in excess is supplied to the free space in the upper portion of the auxiliary chamber 167 by means of a conduit 177, which may include a pressure regulating unit 179, and the discharge of air and stock from the auxiliary chamber 167 is effected through a U-shaped discharge conduit 181. The conduit 181 is desirably mounted so that it may be moved upwardly and downwardly relative to the auxiliary chamber 167 in order that the liquid level within that chamber and within the ponding chamber can be adjusted to the selected value. The outflow end of the conduit 181 is arranged to discharge

into an air separator and stock return unit 183 which connects with the white water system.

In general, the operation of this mechanism is similar to the other embodiments of the invention, and especially the Figure 5 structure. Pressure air, conveniently at a controlled, uniform pressure, is supplied through the conduit 177, the flow control chamber 167 and the conduit 169 to the diffuser tube 171. Stock is supplied to the ponding chamber 165 by way of the stock inflow opening, and normally the stock will be supplied at a uniform, predetermined pressure. The discharge conduit 181 will be located in such a position that when the stock level is at the desired, predetermined height, the amount of air admitted to the ponding chamber 165 will exactly balance the leakage losses from that chamber and any excess delivered to the receiver chamber 167 will be vented to the atmosphere.

If the stock level rises, the amount of air which is vented through the discharge conduit 181 will decrease or will be entirely shut-off. Additional pressure air will thereby be supplied to the interior of the headbox, and in due course, the stock level will return to the normal operating value. If the stock level drops below the predetermined value, more air will be vented from the chamber 167 through the conduit 181 and this will effect a reduction in the pressure within the ponding chamber. Such reduction will cause the stock level to rise and equilibrium conditions will again be restored. As in the arrangements of Figures 4 and 5, it is intended that there will be some discharge of both air and stock during normal operation of the apparatus.

The various embodiments of the invention described in the foregoing are intended to operate under conditions where the pressure maintained above the stock is at a value which is above atmospheric. It may be desirable, under certain conditions, to operate with the stock in the ponding or other flow control chamber at a value which is below atmospheric pressure. One apparatus arranged to operate in this manner is illustrated in Figure 9.

The Figure 9 structure includes a headbox 187, within which there is provided a ponding chamber 189, and an auxiliary chamber 191, the lower end of which is connected by a conduit 193 to the ponding chamber 189, at a point below the level of the stock normally contained therein. The upper end of the auxiliary chamber is connected by another conduit 195 to the ponding chamber at a region above the normal level of the stock contained therein, and to minimize disturbance of the air within the ponding chamber, the conduit 195 terminates in an air inflow diffuser pipe 197, as shown.

Since this apparatus is especially intended to operate under reduced pressure, the auxiliary chamber 191 is connected to a second auxiliary chamber 199 by means of a vertically-adjustable discharge conduit 201. The lower end of the second auxiliary chamber 199 is connected to a stock reservoir 203 by means of a barometric column 205, and the upper end of the second auxiliary chamber 199 is connected to a vacuum pump 207, as illustrated.

During normal operation, the vacuum pump 207 is operable to maintain a predetermined reduced pressure within the second auxiliary chamber 199. This reduced pressure is communicated to the ponding chamber 189 within the headbox 187 by way of the vertically adjustable discharge conduit 201, the first auxiliary chamber 191, the conduit 195 and the diffuser tube 197 located in the upper portion of the headbox. As in the other apparatus, the stock is normally supplied to the headbox chamber at a predetermined uniform pressure.

The adjustment of the position of the discharge conduit 201 is such that when the liquid level of the stock contained within the ponding chamber 189 is at the desired value, the amount of air being withdrawn from the ponding chamber, via the conduit 195, the chamber 191, the conduit 201, the chamber 199 and the pump 207, will

just balance the leakage into the ponding chamber. At this same time, there will also be some continuous discharge of stock by way of the conduit 193, the chamber 195, the chamber 199, and the barometric column 205.

If the stock level within the ponding chamber rises, the amount of air being vented to the second auxiliary chamber 199 will be reduced, due to a reduction or a shutting-off of the opening through which air flows into the inflow end of the discharge conduit 201. This will result in an increase in the pressure within the ponding chamber 189 and a simultaneous increase in the rate at which stock is discharged into the chamber 199 and the barometric column 205. The stock level will thereby be lowered until stability is restored to the system at the preselected stock level.

A lowering of the stock level from the selected operating level will have substantially the opposite effect. More air and less stock will be discharged from the auxiliary chamber until the stock level again rises to the operating level.

Stock which flows into the barometric column 205 and thence into the reservoir 203 at the bottom of that column may be returned to the white water system by a suitable pump, as illustrated at 209. The primary function of the second auxiliary chamber 199 and the barometric column 205 is to effect separation of the air and stock discharged from the conduit 201, and other structural arrangements capable of accomplishing this function can obviously be substituted therefor.

It will be understood that an arrangement such as that shown in Figure 9 may include an air inflow conduit such as the perforated pipe diffusion unit illustrated at 77 in Figures 1 and 4. When such a unit is used, it should be throttled to reduce substantially the amount of air admitted to the headbox ponding chamber. The use of a controllable air inflow will, however, facilitate somewhat the control of the pressure and stock level being maintained within the ponding chamber. As in the previously described structures, an excess of air is supplied to the ponding chamber during normal operation.

It will also be understood that apparatus in accordance with the invention can be used to accomplish stock level control in other portions of the stock delivery system of a papermaking machine. For example, stock delivery conduits such as the conduit illustrated at 27 in Figure 1, sometimes include an enlarged cross-sectional area portion, as illustrated at 211, which may be used to accomplish a deaeration or other function. To that end, it is usual to maintain a reduced pressure above the stock as it passes through the enlarged conduit portion, by providing a connection to a vacuum pump or other source of reduced pressure. To avoid flow disturbances in the stock passing through the enlarged conduit portion, which disturbances often carry through to the web-forming region, and to maintain the stock level at a preselected value, independently of the actual pressure maintained above the stock, the apparatus may desirably include a level regulating means in accordance with the invention, as for example the apparatus illustrated in Figure 9.

The various arrangements described in the foregoing constitute convenient and reliable means for maintaining a body or a flowing stream of stock within a headbox or other flow control chamber at a predetermined level which is independent of the total pressure or head which exists within that body or flowing stream of stock, and which is also independent of change in the rate of flow of the stock. The described mechanisms and procedures accomplish the desired result, under such conditions that there is substantially no disturbance of the surface of the body of stock within the headbox chamber, and without the creation of any surges or other undesirable flow conditions within the stock body.

While the invention has particular utility in connection with the operation of pressurized headbox equipment

wherein the stock is maintained under a positive pressure and at a depth which is lower than about eighteen inches, this by no means defines its useful limits. The arrangement can be used to control stock level under conditions of reduced pressure and to control headbox operation in accordance with factors other than stock level. For example, the invention lends itself to use in instances where it is desired to effect control of the total pressure head at the slice, or elsewhere, without necessarily maintaining a fixed stock level. It can also be used in instances where control in response to stock turbulence is being accomplished.

Certain of the embodiments of the invention embody no moving parts, and all of the disclosed arrangements are structurally simple and completely reliable in operation.

Various of the features of the invention believed to be new are set forth in the appended claims.

We claim:

1. In apparatus of the class described, means defining the walls of an enclosed chamber which is adapted to receive a body of stock, said chamber having a stock inflow opening and a stock outflow opening located below the normal level of the body of stock which is contained therein, means for delivering stock continuously to said chamber through said stock inflow opening, said apparatus being adapted to discharge stock continuously through said outflow opening, means defining the walls of an auxiliary enclosed chamber, the vertical dimension and position of said auxiliary chamber being such that its upper and lower ends are respectively located substantially above and substantially below the normal level of the stock contained within said stock chamber, the lower end of said auxiliary chamber connecting with said stock chamber at a point which is a substantial distance below the normal level of the stock contained within said stock chamber, the upper end of said auxiliary chamber connecting with said stock chamber at a point which is spaced a substantial distance above the normal level of the stock contained in that chamber, means operable to deliver air which is at a pressure greater than the pressure normally existing within said stock chamber to the interior of said stock chamber, said air delivery means including a source of pressure air, an air conduit which terminates in an air diffusing discharge unit disposed within said stock chamber a substantial distance above the normal level of the stock contained in that chamber, and means responsive to the level of the stock contained within said auxiliary chamber for controlling the pressure of the air within said stock chamber, thereby to regulate the level of the stock within that chamber.

2. In apparatus of the class described, means defining the walls of an enclosed chamber which is adapted to contain a body of stock, said chamber having spaced-apart stock inflow and stock outflow openings located below the normal level of the stock which is contained therein, means for delivering stock to said stock chamber through said stock inflow opening, said apparatus being adapted to discharge stock through said outflow opening, means defining the walls of an auxiliary enclosed chamber, the vertical dimension and position of said auxiliary chamber being such that its upper and lower ends are respectively located substantially above and substantially below the normal level of the stock contained within said stock chamber, a stock conduit which connects the lower end of said auxiliary chamber to said stock chamber at a point which is a substantial distance below the normal level of the stock contained within said stock chamber, air conduit means which terminates in the upper portion of said stock chamber, connecting the upper end of said auxiliary chamber to said stock chamber at a point which is spaced a substantial distance above the normal level of the stock contained within said stock chamber, means operable to produce a continuous flow of air which is at a pressure greater than the pressure existing within the said stock chamber into the interior of said stock

chamber, said flow producing means including a source of pressure air and an air conduit which terminates in an air diffusing discharge unit disposed within said stock chamber a substantial distance above the normal level of the stock contained in that chamber, and means responsive to the level of the stock contained within said auxiliary chamber for controlling the rate of flow of pressure air into said stock chamber, thereby to regulate the level of the stock within that chamber.

3. In apparatus of the class described, means defining the walls of an enclosed chamber which is adapted to contain a body of stock, said chamber having spaced-apart stock inflow and stock outflow openings located below the normal level of the stock which is contained therein, means for delivering a flowing stream of stock, which is under pressure, to said stock chamber through said stock inflow opening, said apparatus being adapted to discharge stock through said outflow opening, means defining the walls of an auxiliary enclosed chamber, the vertical dimension and position of said auxiliary chamber being such that its upper and lower ends are respectively located substantially above and substantially below the normal level of the stock contained within said stock chamber, a stock conduit which connects the lower end of said auxiliary chamber to said stock chamber at a point which is below the normal level of the stock contained within said stock chamber, air conduit means, which terminates in the upper portion of said stock chamber, connecting the upper end of said auxiliary chamber to said stock chamber at a point which is spaced above the normal level of the stock contained within said stock chamber, a normally open vent line which terminates within said auxiliary chamber, means including a source of air which is at a pressure greater than that normally maintained within said stock chamber, for producing a flow of air into the upper portion of said stock chamber, and means operable in response to the level of the stock contained within said auxiliary chamber to effect at least an intermittent, controlled flow of pressure air through said air conduit means from said stock chamber into said auxiliary chamber and thence out of said auxiliary chamber via said vent line, thereby to regulate the level of the stock within said stock chamber.

4. Apparatus in accordance with claim 3, wherein the vent line which extends into said auxiliary chamber terminates in an air vent opening having a substantial vertical dimension, whereby the area of said air vent opening is automatically varied in response to the level of the stock contained within said auxiliary chamber.

5. In apparatus of the class described, means defining the walls of an enclosed chamber which is adapted to contain a body of stock, said chamber having spaced-apart stock inflow and stock outflow openings located below the normal level of the stock which is contained therein, means for delivering stock to said chamber through said stock inflow opening, said apparatus being adapted to discharge stock through said outflow opening, means defining the walls of an auxiliary enclosed chamber, the vertical dimension and position of said auxiliary chamber being such that its upper and lower ends are respectively located substantially above and substantially below the normal level of the stock contained within said stock chamber, the lower end of said auxiliary chamber connecting with said stock chamber at a point which is below the normal level of the stock contained within said stock chamber, the upper end of said auxiliary chamber connecting with said stock chamber at a point which is spaced a substantial distance above the normal level of the stock contained in that chamber, means for producing at least an intermittent flow of air which is at a pressure greater than the pressure existing within said stock chamber into the interior of said stock chamber, and means including a combination air and stock discharge conduit which extends into

said auxiliary chamber and which is operable, depending upon the stock level in said auxiliary chamber, to discharge air, stock or mixtures thereof from said auxiliary chamber, thereby maintaining a predetermined stock level within said stock chamber.

6. In apparatus of the class described, means defining the walls of an enclosed chamber which is adapted to contain a body of stock, said chamber having spaced-apart stock inflow and stock outflow openings located below the normal level of the stock which is contained therein, means for delivering a flowing stream of stock, which is under pressure, to said stock chamber through said stock inflow opening, said apparatus being adapted to discharge stock through said outflow opening, means defining the walls of an auxiliary enclosed chamber, the vertical dimension and position of said auxiliary chamber being such that its upper and lower ends are respectively located substantially above and substantially below the normal level of the stock contained within said stock chamber, a stock conduit which connects the lower end of said auxiliary chamber to said stock chamber at a point which is a substantial distance below the normal level of the stock contained within said stock chamber, and air conduit connecting the upper end of said auxiliary chamber to said stock chamber at a point which is spaced a substantial distance above the normal level of the stock contained in that chamber, means including a source of pressure air and a conduit which terminates in an air diffusing unit located within said stock chamber, for producing at least an intermittent flow of air which is at a pressure greater than the pressure existing within said stock chamber into that chamber, and means including a combination air and stock discharge conduit which extends into said auxiliary chamber and which is operable, depending on the stock level in said auxiliary chamber, to discharge air, stock or mixtures thereof from said auxiliary chamber, thereby maintaining a predetermined stock level within said stock chamber.

7. A stock feed device for a papermaking machine comprising a closed headbox having stock inlet and stock outlet openings in spaced relation to each other and an enclosed ponding chamber therebetween, means for delivering stock, under pressure, to said ponding chamber via said stock inlet opening, means defining the walls of an auxiliary enclosed chamber, the vertical dimension and position of said auxiliary chamber being such that its upper and lower ends are respectively located substantially above and substantially below the normal level of the stock contained within said ponding chamber, stock conduit means connecting the lower end of said auxiliary chamber to said ponding chamber at a point which is below the normal level of the stock within that chamber, air conduit means connecting the other end of said auxiliary chamber to said ponding chamber at a point which is spaced above the normal level of the stock contained in said ponding chamber, a source of pressure air, means including an air diffusion unit located within said headbox for discharging air from said pressure source into said ponding chamber under such conditions that disturbance of the surface of the stock contained within said ponding chamber is substantially avoided, and means responsive to the level of liquid within said auxiliary chamber for controlling the delivery of pressure air to said ponding chamber, thereby to regulate the level of the stock within said ponding chamber.

8. A stock feed device for a papermaking machine comprising means defining the walls of a closed headbox having stock inflow and stock outflow openings in spaced relation to each other and an enclosed ponding chamber therebetween, said inflow and outflow openings being located below the normal level of the stock which is contained within said ponding chamber, means for delivering stock under pressure to said ponding chamber through said stock inflow opening, said device being adapted to discharge stock continuously through

said outflow opening, and means for maintaining the body of stock which is contained within said ponding chamber at a predetermined level during the operation of said apparatus, including means defining the walls of an auxiliary enclosed chamber, the vertical dimension and position of said auxiliary chamber being such that its upper and lower ends are respectively located substantially above and substantially below the normal level of the stock contained within said ponding chamber, a stock conduit which connects the lower end of said auxiliary chamber to said ponding chamber at a point which is below the normal level of the stock contained within said ponding chamber, an air conduit means, which terminates in the upper portion of said ponding chamber, connecting the other end of said auxiliary chamber to said ponding chamber, means including a conduit which terminates in an air diffusion mechanism located in the upper portion of said ponding chamber for continuously admitting air at a pressure which is greater than the pressure existing within said ponding chamber to the interior of said ponding chamber, and means including a discharge conduit which extends into said auxiliary chamber and which is adapted to discharge pressure air from said ponding chamber by way of said auxiliary chamber at a variable rate responsive to the level of the stock within said stock chamber.

9. A stock feed device for a papermaking machine comprising means defining the walls of a closed headbox having spaced-apart stock inflow and stock outflow openings in spaced relation to each other and an enclosed ponding chamber therebetween, means for delivering stock under pressure to said ponding chamber through said stock inflow opening, said device being adapted to discharge stock continuously through said outflow opening, and means for maintaining the body of stock which is contained within said ponding chamber at a predetermined level during the operation of said apparatus, said level maintaining means including means defining the walls of an auxiliary enclosed chamber, the vertical dimension and position of said auxiliary chamber being such that its upper and lower ends are respectively located substantially above and substantially below the normal level of the stock contained within said ponding chamber, a stock conduit which connects the lower end of said auxiliary chamber to said ponding chamber at a point which is below the normal level of the stock contained within said ponding chamber, means connecting the other end of said auxiliary chamber to said ponding chamber at a point which is spaced above the normal level of the stock contained in said ponding chamber, means including an air conduit which terminates in an air diffusion mechanism located in the upper portion of said ponding chamber for admitting pressure air into said ponding chamber without disturbing the surface of the stock contained within that chamber, and means including a float valve responsive to the level of the stock within said auxiliary chamber for controlling the rate at which pressure air is admitted to said ponding chamber.

10. A stock feed device for a papermaking machine, comprising a closed headbox having stock inlet and stock outlet openings in spaced relation to each other and an enclosed ponding chamber therebetween, means for delivering stock, under pressure, to said ponding chamber via said stock inlet opening, said device being adapted to discharge stock continuously through said outflow opening, means defining the walls of an auxiliary enclosed chamber, the vertical dimension and position of said auxiliary chamber being such that its upper and lower ends are respectively located substantially above and substantially below the normal level of the stock contained within said ponding chamber, stock conduit means connecting the lower end of said auxiliary chamber to said ponding chamber at a point which is below the normal level of the stock within that chamber, air conduit means which terminates in the upper portion of

said ponding chamber connecting the upper end of said auxiliary chamber to said ponding chamber, a source of pressure air, means including a conduit which terminates in an air diffusing mechanism located at the upper portion of said stock chamber for discharging air from said pressure source into the upper portion of said ponding chamber, said air being discharged into said ponding chamber at a pressure which is greater than the pressure normally existing within said ponding chamber, and means including an adjustable vent line which extends into said auxiliary chamber and which is operable, depending upon the stock level in said ponding chamber, to discharge air, stock or mixtures thereof from said auxiliary chamber, thereby maintaining a predetermined stock level within said stock chamber.

11. A stock feed device for a papermaking machine comprising a closed headbox having stock inlet and stock outlet openings in spaced relation to each other and an enclosed ponding chamber therebetween, means for delivering stock under pressure to said ponding chamber via said stock inlet opening, said device being adapted to discharge stock continuously through said outflow opening, means defining the walls of an auxiliary enclosed chamber, the vertical dimension and position of said auxiliary chamber being such that its upper and lower ends are respectively located substantially above and substantially below the normal level of the stock contained within said ponding chamber, stock conduit means connecting the lower end of said auxiliary chamber to said ponding chamber at a point which is below the normal level of the stock within that chamber, means comprising a conduit which terminates in an air diffusion mechanism located within said ponding chamber for connecting the upper end of said auxiliary chamber to said ponding chamber at a point which is spaced above the normal level of the stock contained in said ponding chamber, means including a source of pressure air and a second conduit connected to the upper end of said auxiliary chamber for admitting pressure air into that chamber, at a pressure which is greater than the pressure normally existing within said ponding chamber, and means including a combination air and stock discharge conduit which extends into said auxiliary chamber and which is operable to discharge air, stock or mixtures thereof from said auxiliary chamber, thereby to control the delivery of pressure air to said ponding chamber and to maintain a predetermined stock level within said ponding chamber.

12. A stock feed device for a papermaking machine comprising a closed headbox having stock inlet and stock outlet openings in spaced relation to each other and an enclosed ponding chamber therebetween, means for delivering stock under pressure to said ponding chamber via said stock inlet opening, said device being adapted to discharge stock continuously through said outflow opening, means defining the walls of an auxiliary enclosed chamber, the vertical dimension and position of said auxiliary chamber being such that its upper and lower ends are respectively located substantially above and substantially below the normal level of the stock contained within said ponding chamber, stock conduit means connecting the lower end of said auxiliary chamber to said ponding chamber at a point which is below the normal level of the stock within that chamber, means comprising a conduit which terminates in an air collecting mechanism located within said stock chamber for connecting the upper end of said auxiliary chamber to said ponding chamber at a point which is spaced above the normal level of the stock contained in said ponding chamber, a combination air and stock discharge conduit which extends into said auxiliary chamber and which is operable, depending upon the stock level in said auxiliary chamber, to discharge air, stock or mixtures thereof from said auxiliary chamber, thereby maintaining a predetermined stock level within said stock chamber, means

defining the walls of a second auxiliary chamber connected to the outlet end of said air and stock discharge conduit and means associated with said second auxiliary chamber for maintaining a predetermined pressure therein.

13. The method of operating a pressurized headbox which comprises delivering stock to the headbox at a predetermined pressure, and simultaneously maintaining the level of the stock at a predetermined value, which is independent of the pressure of the stock, by admitting air to the interior of the headbox at a pressure which is greater than the pressure normally maintained within said headbox, and, at the same time, discharging, in response to the level of stock in the headbox, air, stock, or mixtures thereof from the headbox at levels which are different from the level of the stock in the headbox, and under such conditions that there is substantially no disturbance at or beneath the surface of the stock within the headbox.

14. The method of operating a pressurized headbox which comprises delivering a flowing stream of stock to the headbox at a predetermined pressure, and simultaneously maintaining the level of the stock at a predetermined value, which is independent of the pressure of the stock, by diffusely admitting air to the interior of the headbox at a pressure which is greater than the pressure normally maintained within said headbox, and at the same time discharging, in response to the level of stock in the headbox, air, stock, or mixtures thereof from the headbox at individually variable rates, at levels which are different from the level of the stock in the headbox, and under such conditions that such discharge produces substantially no disturbance at or beneath the surface of the stock within the headbox.

15. Apparatus in accordance with claim 8 wherein the discharge conduit which extends into said auxiliary chamber terminates in an air vent opening having a substantial vertical dimension, whereby the area of said air vent opening is automatically varied in response to the level of the stock contained within said auxiliary chamber.

16. A stock feed device for a papermaking machine comprising a closed headbox having stock inlet and stock outlet openings in spaced relation to each other, and an enclosed ponding chamber therebetween, means for delivering stock under pressure to said ponding chamber via said stock inlet opening, means defining the walls of an auxiliary enclosed chamber, the vertical dimension and position of said auxiliary chamber being such that its upper and lower ends are respectively located substantially above and substantially below the normal level of the stock contained within said ponding chamber, stock conduit means connecting the lower end of said auxiliary chamber to said ponding chamber at a point which is a substantial distance below the normal level of the stock contained within that chamber, air conduit means connecting the other end of said auxiliary chamber to said ponding chamber, said air conduit means terminating within said headbox in a perforated tube disposed a substantial distance above the normal level of the stock contained in said ponding chamber, means for producing at least an intermittent flow of air which is at a pressure greater than the pressure existing within said stock chamber into the interior of said stock chamber, and means responsive to the level of the stock contained within said auxiliary chamber for controlling the pressure of the air within said stock chamber, thereby to regulate the level of the stock within said chamber.

17. The method of operating a pressurized stock feed device having an enclosed stock chamber through which the stock flows, which comprises delivering stock to the stock chamber at a predetermined pressure, and simultaneously maintaining the level of the stock within said chamber at a predetermined value, which is independent of the pressure at which the stock is delivered to said chamber by diffusing air into the interior of the stock chamber at a pressure which is greater than the pres-

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sure normally maintained within said headbox, and at a rate which is in excess of normal leakage from said chamber, and at the same time, discharging, from said chamber, in response to the level of stock therein, air, stock, or mixtures thereof, thereby to control the pressure of the air within said stock chamber and to regulate the level of the stock within that chamber.

18. In apparatus of the class described, means defining the walls of an enclosed chamber which is adapted to receive a body of stock, said chamber having a stock inflow and a stock outflow opening located below the normal level of the body of stock which is contained therein, means for delivering stock continuously to said chamber through said stock inflow opening, said apparatus being operable to discharge stock continuously through said outflow opening, means operable to deliver air which is at a pressure greater than the pressure normally existing within said stock chamber to the interior of said stock chamber, said air delivery means including a source of pressure air and an air conduit which terminates in an air diffusing discharge unit disposed within said stock chamber a substantial distance above the normal level of the stock contained in that chamber, and means responsive to the level of the stock within said chamber for con-

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trolling the delivery of air into said chamber, thereby to regulate the level of the stock within said chamber.

19. Apparatus as defined in claim 18 wherein said means for controlling the delivery of air into said chamber comprises means operable in response to the level of the stock in said stock chamber to discharge air, stock or mixtures thereof from said stock chamber.

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