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PAPERMAKING HEADBOX WITH ADJUSTABLE HYDRAULIC NOZZLE AND SLICE

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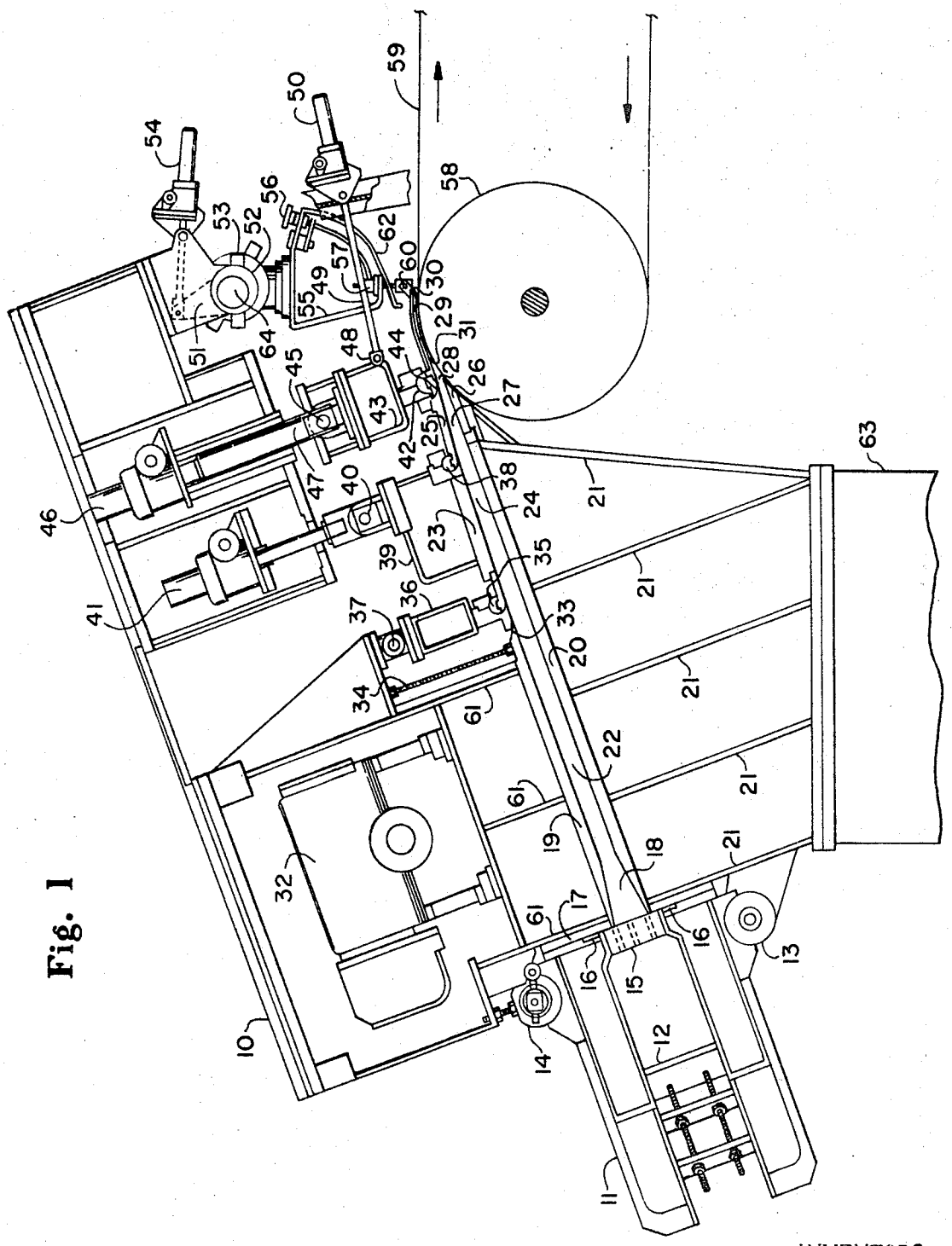


Fig. 1

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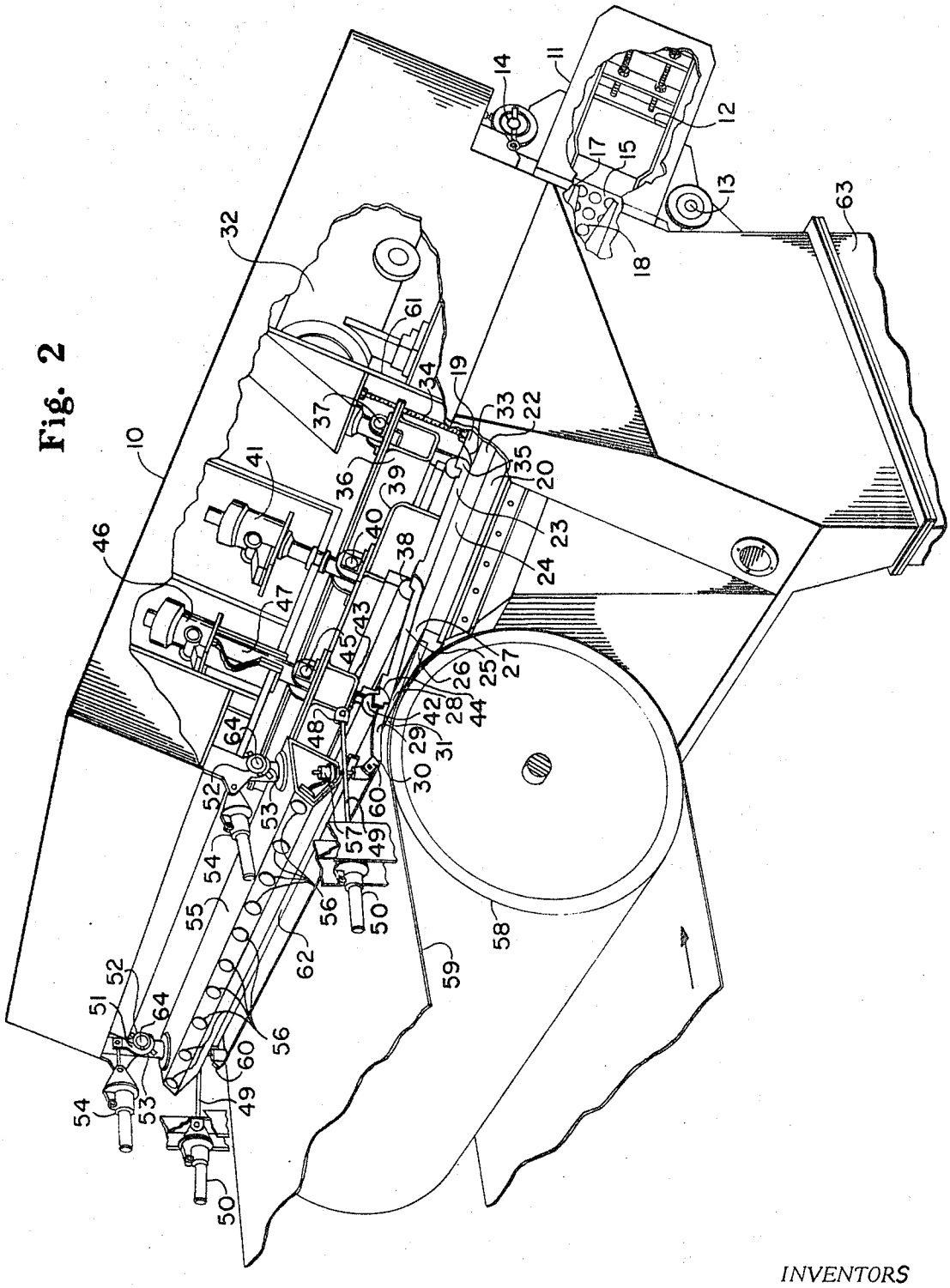
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Fig. 2



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PAPERMAKING HEADBOX WITH ADJUSTABLE HYDRAULIC NOZZLE AND SLICE

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ABSTRACT OF THE DISCLOSURE

An adjustable pressure nozzle for the delivery of papermaking furnishes to foraminous media in the high speed production of paper and wet laid nonwovens, which adjustable pressure nozzle is provided with articulation in its various roof sections and throat. Either or both the formation zone and throat of the adjustable pressure nozzle can be adjusted and thereafter maintained in position while the convergence angles in the approach channel preceding the throat remain adjustable by employing pivotable knuckles between the various roof sections, each knuckle being connected to an individual knuckle pivot, the knuckles downstream of the approach channel being vertically adjustable; and by employing an expansion knuckle upstream of the approach channel. The adjustable pressure nozzle provides means and process whereby tensile ratio adjustments are conveniently effected during paper formation while the formation zone length and geometry are fixed.

BACKGROUND OF THE INVENTION

This invention relates to headboxes for the delivery of fibrous slurries and papermaking furnishes to foraminous media in papermaking and wet-laid nonwoven formation processes. More particularly, the invention relates to headboxes of the hydraulic or pressure nozzle type which are equipped with a vertically tapered or converging rectangular passage through which fibrous slurry or furnish passes, which rectangular passage has one or more means for adjusting its critical geometry to achieve response in paper formation characteristics.

Specifically, the invention, described herein in terms of paper processing, provides an adjustable pressure nozzle with suitable hydraulic characteristics for high speed paper production wherein means are provided for adjusting the convergence angles or vertical tapers in the several nozzle approach channels. The adjustments in the adjustable pressure nozzle can be accomplished during continuous paper formation while maintaining desired combinations of nozzle throat clearance and formation zone length. Processes for regulating tensile ratio in paper during continuous paper formation are also provided.

Papermaking headboxes of considerable complexity have been proposed heretofore for the delivery of papermaking furnishes to Fourdrinier wires and other foraminous media. For example, U.S. 2,418,600, issued to H. M. Ostertag on Apr. 8, 1947, discloses a headbox having adjustable joints or knuckles connecting the various sections of its roof. Also, U.S. 2,995,485, issued to C. A. Lee on Aug. 8,.1961, discloses a headbox for a paper machine, which headbox is equipped with means for adjusting the machine direction and vertical adjustment of the slice

roof tip in relation to the vertical center line and formation zone of the breast roll.

In spite of the availability of prior art headboxes affording a considerable degree of mechanical adjustment, applicants are unaware of any headbox configuration which affords an adjustable pressure nozzle with sufficient roof articulation of the proper type to permit an adjustment in nozzle convergence angles while maintaining desired combinations of nozzle throat clearance and formation zone length during continuous papermaking operations.

An adjustable pressure nozzle permitting running changes of convergence angle while maintaining a desired formation zone length and geometry has been found to be quite beneficial in contributing to the formation of lightweight tissue, other papers and wet-laid nonwovens at high machine speeds. In general, those skilled in the papermaking arts are aware that the convergence angles in a pressure nozzle headbox affect the machine direction alignment or disalignment of fibers deposited during sheet formation. Fibers are aligned by the increased acceleration induced by high convergence angles; pressure nozzles having lesser convergence angles promote random fiber deposition in formation. Fiber alignment results in high machine direction tensile, but low cross-machine direction tensile in paper. Random fiber deposition results in paper exhibiting tensile strengths which are more nearly equal in both the machine nad cross-machine directions. At the same time paper machine operation at given paper formation speeds, furnish consistencies and breast roll vacuum conditions requires a commensurate formation zone length for furnish water drainage and spouting prevention. If the formation zone length can be maintained constant, then convergence angle adjustment will provide ideal tensile control and control response to changes in furnish freeness.

By means of the convergence angle or vertical taper adjustment the amount and direction of fiber orientation obtained within the adjustable pressure nozzle during continuous papermaking and other wet-laid nonwoven web forming operations is affected. Expressed in another conventional term of the art fiber orientation or alignment controls to a large degree the machine direction tensile strength to cross-machine direction tensile strength ratio, or simply the tensile ratio, in wet-laid nonwoven webs and papers.

The most careful calculation of the proper convergence angle, i.e., the angle included between the floor and roof of a pressure nozzle in the approach channel, to be used in a pressure nozzle can only satisfy one set of wet-laid nonwoven web, including paper, formation conditions or the hydraulic equivalent thereof. The adjustable pressure nozzle of the present invention affords means whereby the hydraulic characteristics of a pressure nozzle can be precisely controlled during continuous papermaking operations to affect fiber orientation.

Although the pressure nozzles heretofore disclosed for use in papermaking have afforded certain adjustments in their geometry, their configuration and articulation has been such that articulation of their nozzle adjustments caused changes in either or both their formation zone length and nozzle throat clearance. The changes in formation zone length accompanying convergence angle changes in these pressure nozzles either introduced such gross changes in formation that precise tensile ratio control

was difficult to achieve or caused paper breaks necessitating paper machine shutdown in order to adjust to new conditions.

SUMMARY OF THE INVENTION

Applicants discovered and developed the present adjustable pressure nozzle configuration in order to provide a selected formation zone length and nozzle throat configuration in conjunction with means for tensile strength response adjustments in a pressure nozzle which could provide the desired adjustment advantages during continuous paper formation. In this way applicants have provided an adjustable pressure nozzle which is adapted to the fine hydraulic control of paper formation which is difficult or impossible to achieve without the continuity of response afforded by adjustment during continuous paper formation.

Briefly stated, in accordance with one embodiment of the invention, there is provided an adjustable pressure nozzle for the delivery of fibrous slurry onto a moving foraminous media in a papermaking machine, which adjustable pressure nozzle defines a vertically converging rectangular passage comprised essentially of an approach channel, a nozzle throat and a formation zone. The adjustable pressure nozzle is provided with means for adjusting the convergence angles in its approach channel while maintaining its nozzle throat and formation zone in a fixed configuration, preferably after initial adjustment. The roof of the pressure nozzle is provided with an expansion joint to allow maintaining the slice roof tip and nozzle throat in a desired position, while knuckle pivots and adjustment jacks provide for convergence angle and nozzle throat clearance adjustments. An eccentric lever and a cam lift, all providing an eccentric cam pivot, provide means for either initial or later desired adjustment of formation zone length and clearance between the slice roof and Fourdrinier wire.

Accordingly, it is an object of this invention to overcome the aforementioned problems and disadvantages while providing an adjustable pressure nozzle equipped with meaningful and precisely adjustable articulatory means.

It is another object of this invention to provide an adjustable pressure nozzle having adjustments whereby the alignment of the papermaking fibers can be controlled in the pressure nozzle and at the formation zone to result in paper which more nearly utilizes the ultimate tensile strength producing capability of a given paper furnish in both the machine and cross-machine directions.

A further object of this invention is to provide a papermaking headbox of the nozzle type which provides for maintaining a chosen nozzle throat clearance and formation zone length while enabling running changes in the convergence angle of the nozzle approach channel.

Yet another object of this invention is to provide processes for tensile ratio control during continuous paper formation.

BRIEF DESCRIPTION OF THE DRAWINGS

While the specification concludes with claims particularly pointing out and distinctly claiming the subject matter regarded as forming the present invention, it is believed that the invention will be better understood from the following description taken in connection with the accompanying drawings in which like numbers refer to like nozzle elements and features:

FIG. 1 is a cross-sectional side elevation of a preferred embodiment of the present papermaking headbox constructed in accordance with this invention with the objective of showing the essential features thereof; and

FIG. 2 is a perspective view of the preferred embodiment of the papermaking headbox illustrated in FIG. 1 with parts cut away in order to facilitate the illustration of important details.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In describing the preferred embodiment of the invention illustrated in the drawings, specific terminology will be resorted to for the sake of clarity. It is not intended, however, to be limited to the specific terms so selected, and it is to be understood that each specific term includes all technical equivalents thereof which operate in a similar manner to accomplish a similar purpose.

Referring now to the specific embodiment of the papermaking headbox or adjustable pressure nozzle selected for illustration in FIGS. 1 and 2, the number **10** designates generally a papermaking headbox of the adjustable pressure nozzle type as contemplated by the present invention. Papermaking headbox **10** is equipped with headbox inlet enclosure **11** for introducing papermaking furnish or fibrous slurry into nozzle entry channel **18**. Back channel roof **19** of back channel **22** can be adjusted and fixedly positioned, by means of shims and fastening means during erection and subsequently during cessation of paper formation, to affect the relative angular convergence and position of back channel roof **19** with respect to back channel floor **20**. Thereafter the position of back channel roof **19** remains fixed during paper formation. Adjustment means, further detailed below, are provided for effecting running adjustments of the position of slice roof **29** and nozzle throat **28**, in the machine and vertical directions, with resepct to apron **26** and Fourdrinier wire **59** on breast roll **58**. Slice roof tip **30** can also be vertically adjusted along its length by means of slice micro-jacks **57** of which several are provided in spacing along the length of slice roof tip **30**, only two of which are illustrated in FIG. 2 to avoid confusion, to provide desired profile control of the paper sheet as formed.

FIGS. 1 and 2 illustrate a papermaking headbox **10** in which the convergence angle or taper in approach channel **24**, angle channel **27** and formation zone **31** can all be adjusted and maintained in position independent from the machine direction position of slice roof tip **30** and nozzle throat **28**, within the adjustment travel limits provided and while continuously forming a sheet of paper. It will be noted that both approach channel **24** and angle channel **27**, although independently articulated, are in effect a single approach channel in that they provide for the vertical convergence of furnish toward nozzle throat **28**. Other embodiments of the present adjustable pressure nozzle could be provided with a single approach channel provided with knuckle and expansion articulation in its roof. The adjustment means provided make possible the maintenance of a desired length in formation zone **31**, extending from the end of apron **26** to slice roof tip **30** while adjusting the vertical convergence or taper in approach channel **24** and angle channel **27**.

Papermaking headbox **10** includes means for distributing a paper furnish within nozzle entry channel **18** by means of the holes in distributor plate **15**. Adjustment of the furnish distribution and velocity through distributor plate **15** and across the width of nozzle entry channel **18** is facilitated by adjustable bow plate **12** which can be adjusted and fixed in position to equalize furnish flow across the width of distributor plate **15** and nozzle entry channel **18**. Distributor plate **15** is equipped with headbox inlet hinge **13** and headbox inlet latch **14**. Distributor plate gaskets **16** are also provided to effect a seal between distributor plate **15** and nozzle entry plate **17**.

Papermaking furnish is supplied to distributor plate **15** by headbox inlet enclosure **11**, which in FIGS. 1 and 2 is illustrated as the headbox inlet enclosure **11** which is the subject matter of U.S. 3,272,233, issued to Alton D. Trufitt on Sept. 13, 1966, but, for example, can consist of any of the tapered duct, manifold piping, and side entry tapered flow distributors used conventionally in the industry. Papermaking headbox **10** is also provided with

expansion knuckle 33, which provides machine direction expansion for approach roof 23 and angle roof 25 during convergence angle adjustment, and with first approach knuckle 35. There is also provided a second approach knuckle 38. Breast roll lift gear motor 32, although not essential to the present invention, is identified for the sake of completeness and acts through a pulley-cable arrangement, not illustrated, to raise and lower breast roll 58.

Distributor plate 15 imparts a controlled amount of vortex disturbance to the fibers in the papermaking furnish during flow therethrough. Nozzle entry plate 17 is operative as a bearing and sealing surface against distributor plate 15. The seal is made complete by distributor plate gasket 16. Several back channel roof crossbeams 61 are provided to support and make rigid back channel roof 19.

Headbox inlet enclosure 11 is hingably mounted to bear against nozzle entry plate 17. The hinge support of headbox inlet enclosure 11 is provided by headbox inlet hinge 13 and headbox inlet latch 14. Headbox inlet enclosure 11 and distributor plate 15 can be rotated downwardly on headbox inlet hinge 13, after loosening headbox inlet latch 14, to expose the mouth of back channel 22, nozzle entry channel 18, for inspection and cleaning.

Entering into the present adjustable nozzle proper, the first section, nozzle entry channel 18, comprises a vertically converging or tapering channel providing transition from distributor plate 15 to back channel 22. Alternately, the entire transition may be made along the total length of back channel 22, and nozzle entry channel 18 can be eliminated. Although nozzle entry channel 18 and back channel 22 are illustrated in the embodiment of the invention depicted in FIGS. 1 and 2 as being bounded or defined by straight lines, back channel floor 20 and back channel roof 19, which define the contour of back channel 22 and nozzle entry channel 18, can take the form of hyperbolic curves or other curved shapes which are conventionally used in papermaking headboxes and in the hydraulic arts. Curved shapes can also be employed in the other roof and floor elements of head box 10.

Back channel roof 19 is positionable by virtue of nozzle entry plate 17 bearing against the face of distributor plate 15 at its entry and by means of first approach knuckle 35 and expansion knuckle 33 at its downstream end. As stated before, back channel roof 19 is adjustable in the illustrated embodiment by means of shims and fastening means including bolts, but is held in fixed position during continuous papermaking operation. In other embodiments of the present adjustable pressure nozzle, back channel roof 19 could be articulated in the manner of approach roof 23 and angle roof 25. The downstream end of back channel roof 19 is held upwardly in position against expansion knuckle 33 by expansion knuckle tension rods 34. It will be understood by those skilled in the art that although FIGS. 1 and 2 for clarity show one of a given articulation or means of adjustment, there will be provided multiple means where necessary across the width of the adjustable papermaking nozzle. For example, twenty of the expansion knuckle tension rods 34 are provided across the width of the specific embodiment of papermaking headbox 10 illustrated in FIGS. 1 and 2.

Expansion knuckle 33 and first approach knuckle 35 are provided with further articulation and adjustability by means of their support on first approach knuckle pivot 37. First approach knuckle pivot 37 and first approach knuckle crossbeam 36 serve as supports, acting through first approach knuckle 35, for the entry or upstream end of approach roof 23. Approach roof 23 is supported at its downstream end by second approach knuckle 38, mounted on second approach knuckle crossbeam 39. Second approach knuckle 38 also supports the entry or upstream end of angle roof 25 whose downstream end is supported by outer throat knuckle 44. Alternately, outer throat knuckle 44 can be an expansion knuckle similar to expansion knuckle 33. Outer throat knuckle 44 also serves together with the downstream end of apron 26 to partially define the nozzle throat 28 at the entry to formation zone 31 above and on Fourdrinier wire 59 supported by breast roll 58. Formation zone 31 is further enclosed and defined by slice roof 29. The entire headbox is supported on mounting support 63, and back channel floor 20 is supported on and made stable by multiple back channel floor crossbeams 21.

Second approach knuckle pivot 40 and second approach knuckle 38 together with outer throat knuckle 44 are provided for the articulation of approach roof 23 and angle roof 25. The actual positioning and adjustment of angle roof 25 is accomplished by means of approach adjustment jack 41 and throat adjustment jack 46. Approach adjustment jack 41 is also used to position the downstream end of approach roof 23. The downstream end of back channel floor 20 is connected to apron 26, which is mounted in close proximity to Fourdrinier wire 59 on the periphery of breast roll 58. Throat adjustment slide and bushing 47, actuated by throat adjustment jack 46, together with throat knuckle pivot 45 is used to adjust and articulate throat knuckle 42 and nozzle throat 28. The clearance and adjustment of nozzle throat 28 is made more rigid by throat knuckle crossbeam 43. Throat knuckle 42 is further adjusted and held in the machine direction by slice overhang adjustment jack 50 acting through slice overhang adjustment rod 49, slice overhang adjustment pivot 48 and throat knuckle crossbeam 43. Alternately, slice overhang adjustment jack 50 acting through slice overhang adjustment rod 49 can be pivotally attached to slice roof tip 30. In this attachment position the length of formation zone 31 can be fixed while nozzle throat 28 remains adjustable. In the attachment position illustrated in FIGS. 1 and 2, the length of formation zone 31 is adjusted by altering the machine direction of throat knuckle 42. In another alternate embodiment of the present adjustable pressure nozzle, nozzle throat 28 and formation zone 31 can be provided in fixed configuration while retaining articulatory means in approach roof 23 and angle roof 25.

Eccentric lever 51 and eccentric pivot 64 is used to position slice roof 29. Also used in this positioning are eccentric slice lift cam 52, slice lift jack 54, eccentric slice lift cam housing 53 and slice roof crossbeam 55. These elements provide machine direction articulation and vertical adjustment for slice roof tip 30. Rotation of slice micro-jack adjustment knob 56 further positions slice roof tip 30 by actuating slice micro-jack 57 and affecting the positioning of slice roof tip 30 through slice roof tip pivot 60. Although only one slice micro-jack 57 is shown in FIG. 1 and two in FIG. 2 to avoid confusion, it will be understood that multiple slice micro-jacks 57 and slice micro-jack adjustment knobs 56 are provided along the length of slice roof tip 30. These multiple slice micro-jacks 57 provide means whereby slice roof tip 30 can be profiled to promote evenness in basis weight across the width of deckle of the paper product. Slice roof crossbeam splash guard 62 extends downwardly from the top of slice roof crossbeam 55 and directs splash onto the top of slice roof 29 where it does not interfere with the structure of the paper being formed.

In operation, papermaking furnish is pumped into headbox 10 through headbox inlet enclosure 11 and distributor plate 15 and proceeds into nozzle entry channel 18. The papermaking furnish then proceeds through back channel 22 and downstream through approach channel 24 to angle channel 27. From angle channel 27 the furnish passes through nozzle throat 28 and proceeds underneath slice roof 29 where the fibers it contains are deposited on an instantaneous section of Fourdrinier wire 59 in formation zone 31 to form paper as Fourdrinier wire 59 proceeds around breast roll 58. Adjustment in

headbox **10** can be made in the manner heretofore described in relation to the various parts of headbox **10**.

In the operation of headbox **10** to regulate tensile ratio in paper, applicants practice a process wherein they adjust slice overhang adjustment jack **5** to achieve an initial formation zone length in formation zone **31**. After the initial adjustment of formation zone length, the machine direction position of slice roof tip **30**, and thusly the formation zone length, is fixed in position. Thereafter the tensile ratio of the paper formed during continuous paper formation is regulated by adjusting the convergence angle in the approach channel, which in the adjustable pressure nozzle embodiment illustrated in FIGS. 1 and 2 is comprised of approach channel **24** and angle channel **27**.

In further methods of operation, applicants can first adjust the nozzle throat clearance in the adjustable pressure nozzle to achieve an initial fibrous slurry velocity through nozzle throat **28** and in formation zone **31**. Fixing the nozzle throat clearance will then have the effect of fixing both the nozzle throat **28** and formation zone **31** configuration while the tensile ratio of the paper formed during continuous paper formation can be adjusted as stated above. Alternately, applicants may adjust and then fix both the nozzle throat clearance and the formation zone length prior to regulating the tensile ratio of the paper formed during continuous papermaking operations by adjusting the convergence angle in the approach channel.

Headbox **10** is especially adapted for use in the manufacture of lightweight tissue where it is desired to control the machine direction-cross machine direction tensile ratio during continuous papermaking operations. Headbox **10** is particularly advantageous in that the convergence angles in approach channel **24** and angle channel **27** can be adjusted while paper is being formed without altering the position of or clearance in nozzle throat **28** after initial adjustment. Therefore, the furnish velocity through nozzle throat **28** and the geometry of formation zone **31** can be maintained while effecting changes in tensile ratio, and it becomes clear from the foregoing detailed explanation that the essence of applicants' invention is the provision of an adjustable pressure nozzle wherein formation zone elements can be fixed in position while effecting adjustments in the approach channel convergence angles during continuous papermaking operations.

It is to be understood that the embodiment of the invention illustrated in FIGS. 1 and 2 is to be taken as a preferred embodiment. Various changes may be made in the shape, size and arrangement of the several apparatus elements without departure from the invention. For example, equivalent elements may be substituted for those illustrated and described herein, and parts may be reversed, while certain features of the invention may be utilized independently of the use of other features, all without departing from the spirit or scope of the invention defined in the appended claims. Papermaking headboxes may be constructed in accordance with this invention from the conventionally used metals and plastics having the necessary rigidity and corrosion characteristics for use in such a device.

Having thus described the invention, what is claimed is:

1. The process of regulating tensile ratio in paper during continuous paper formation by the delivery of fibrous slurry onto a moving foraminous medium through an adjustable pressure nozzle having an approach channel, a nozzle throat and a formation zone capable of adjustment, which process comprises:

(a) adjusting the adjustable pressure nozzle machine direction position to achieve an intial formation zone length,

(b) fixing the machine direction position of the slice roof tip defining the downstream end of said formation zone, and thereafter

(c) regulating the tensile ratio of the paper during continuous paper formation by adjusting the convergence angle in the approach channel without altering said formation zone length.

2. The process of regulating tensile ratio in paper during continuous paper formation by the delivery of fibrous slurry onto a moving foraminous medium through an adjustable pressure nozzle having an approach channel, a nozzle throat and a formation zone capable of adjustment, which process comprises:

(a) adjusting the nozzle throat clearance in the adjustable pressure nozzle to achieve an initial fibrous slurry velocity in the formation zone,

(b) fixing the nozzle throat machine direction position and clearance, and thereafter

(c) regulating the tensile ratio of the paper during continuous paper formation by adjusting the convergence angle in the approach channel without altering said nozzle throat clearance or machine direction position.

3. The process of regulating tensile ratio in paper during continuous paper formation by the delivery of fibrous slurry onto a moving foraminous medium through an adjustable pressure nozzle having an approach channel, a nozzle throat and a formation zone capable of adjustment, which process comprises:

(a) adjusting the nozzle throat clearance in the adjustable pressure nozzle to achieve an initial fibrous slurry velocity in the formation zone,

(b) adjusting the formation zone of the adjustable pressure nozzle to achieve an initial formation zone length,

(c) fixing the nozzle throat clearance and the formation zone length in machine direction position, and thereafter

(d) regulating the tensile ratio of the paper during continuous paper formation by adjusting the convergence angle in the approach channel without altering said formation zone length or nozzle throat clearance.

4. An adjustable pressure nozzle within a headbox for a papermaking machine for delivery of fibrous slurry to a moving foraminous medium; said pressure nozzle comprising a vertically converging rectangular passage means such that the slurry passes through at least a back channel, an approach channel, an angle channel, a nozzle throat, and a formation zone onto said moving foraminous medium; said passage means defined on its roof by a back channel roof, an approach channel roof, an angle channel roof, and a slice roof having a slice tip; said passage means being defined on its floor by a channel floor connected to an apron and by a section of said moving foraminous medium extending beneath and between the apron and the slice roof tip; said back channel roof having a downstream end connected to the headbox by expansion knuckle tension rods such that the downstream end is held upwardly against an expansion knuckle connected to the upstream end of said approach channel roof, said upstream end of said approach channel also comprising a first approach knuckle which is connected to and pivotable about a first approach knuckle pivot; the downstream end of said approach channel roof being pivotally connected to the upstream end of said angle channel roof by a second approach knuckle which is connected to and pivotable about a second approach knuckle pivot, and which is vertically adjustable by means of a connected approach adjustment jack, the downstream end of said angle channel roof being pivotally connected to the slice roof by an outer throat knuckle which is connected to and pivotable about a throat knuckle pivot, and which is vertically adjustable by means of a connected throat adjustment jack, said throat knuckle being adjustable in the machine direction by means of a connected slice overhang adjustment jack and the slice roof tip being vertically adjustable by a micro-jack means; the apparatus coacting such that the throat knuckle and slice roof can be fixed

in machine direction position, by means of the slice overhang adjustment jack, after initial adjustment while the convergence angle to the approach roof and angle roof with respect to the channel floor remains adjustable.

5. An adjustable pressure nozzle for the delivery of fibrous slurry onto a moving foraminous medium in a papermaking machine as defined in claim 4 wherein the outer throat knuckle is an expansion knuckle.

6. An adjustable pressure nozzle for the delivery of fibrous slurry onto a moving foraminous medium in a papermaking machine as defined in claim 4 wherein the tip of the slice roof is pivotally mounted on an eccentric cam pivot.

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