United States Patent [19]

Cowan

[11] **3,922,190**

[45] **Nov. 25, 1975**

[54] **VACUUM DRAINAGE DEVICE HAVING A PLURALITY OF STEPPED BLADES**

[75] Inventor: **Wavell Frederick Cowan,** Montreal West, Canada

[73] Assignee: **Inotech Process Limited,** Montreal, Canada

[22] Filed: **Sept. 10, 1974**

[21] Appl. No.: **504,804**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 395,460, Sept. 10, 1973, abandoned, which is a continuation-in-part of Ser. No. 249,317, May 1, 1972, abandoned.

[52] **U.S. Cl.** **162/352;** 162/374

[51] **Int. Cl.²** **D21F 1/48**

[58] **Field of Search** 162/352, 364, 374, 211

[56] **References Cited**

UNITED STATES PATENTS

2,928,465	3/1960	Wrist	162/352
3,239,409	3/1966	Knowles	162/352
3,497,420	2/1970	Clark	162/352
3,637,460	1/1972	Newsom et al.	162/352

OTHER PUBLICATIONS

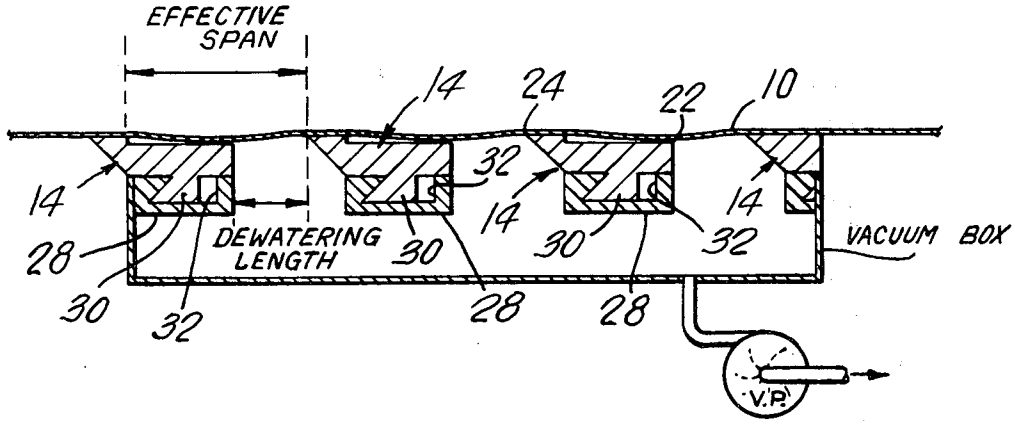
B. A. Thorp, "Hydrofoil Design and Application is an Evolving Science," Paper Trade Journal; Vol. 149, No. 2., Jan. 11, 1965; pages 37–41.

Primary Examiner—S. Leon Bashore
Assistant Examiner—Richard V. Fisher
Attorney, Agent, or Firm—Robert E. Mitchell; Alan Swabey

[57] **ABSTRACT**

A vacuum drainage device for the forming fabric on a Fourdrinier machine which includes a transversely extending vacuum box and a plurality of stationary stepped blades having a flat support surface and a recessed trailing surface which normally does not support the forming fabric. Both water drainage and wire screen motion is effected by a series of these stepped blades. A hydrodynamic nip is formed between the forming fabric and the trailing surface when vacuum is applied by the vacuum box, thereby effectively limiting the drainage suction to the distance between the nip and the leading edge of a succeeding blade.

21 Claims, 2 Drawing Figures



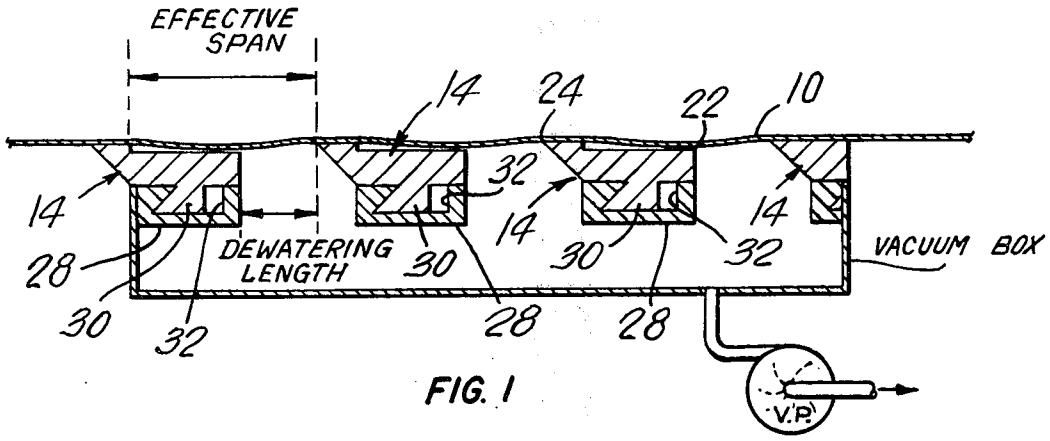

EFFECTIVE SPAN
14
24
22
10
32
14
14
14
28
DEWATERING LENGTH
30
30
32
VACUUM BOX
30
32
28
28
V.P.

FIG. 1

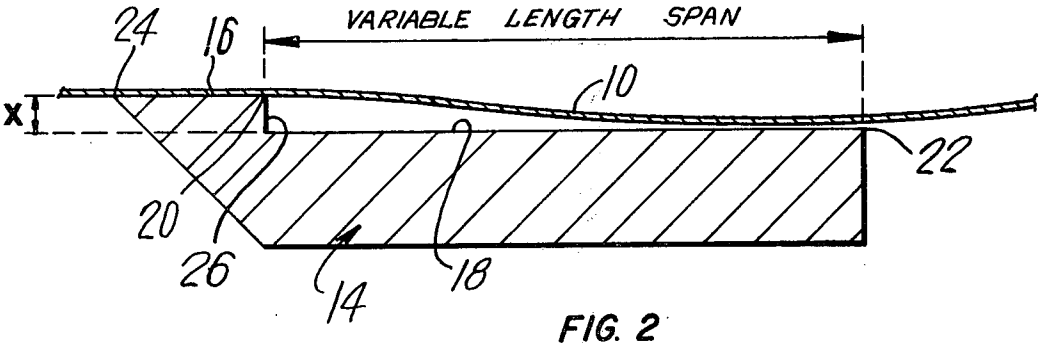

24
16
VARIABLE LENGTH SPAN
10
X
22
20
26
14
18

FIG. 2

VACUUM DRAINAGE DEVICE HAVING A PLURALITY OF STEPPED BLADES

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of U.S. application Ser. No. 395,460, filed Sept. 10, 1973, which was a continuation-in-part of U.S. application Ser. No. 249,317, filed May 1, 1972, both now abandoned.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to paper making and particularly to a drainage stage in the paper-making process.

2. Description of the Prior Art

In Fourdrinier machines, the paper stock is discharged onto a moving forming fabric. At a drainage stage, the forming fabric carrying the stock may be passed over a plurality of table rolls. following the table rolls, normally a plurality of suction boxes are provided which are connected to a vacuum source. The table rolls, as is well known, have a drainage function by the fact that suction is created between the departing surfaces of the roll and the wire screen. The table rolls serve a further function in that they cause the wire screen to agitate slightly thereby keeping the fibers and the stock in movement preventing them from overconcentrating in certain areas which would result in a paper of uneven density.

A problem in using table rolls is that there is no way of controlling the amount of suction provided by the table rolls, nor is there any way of controlling the wire agitation.

Recently, drainage devices have been developed whereby the table rolls are replaced by stationary foils in combination with a vacuum box, such as is described in U.S. Pat. No. 2,928,465, Wrist, 1960. In such foils, the angle of divergence of the surface trailing the support surface of the foil is less than 5° so that it is equivalent to the departing surface of the table roll for purposes of drawing water from the stock on the forming fabric and for pulling down on the forming fabric in order to agitate it in the vertical plane. However, if it is necessary to reduce the amount of concentrated vacuum area on the fabric and stock, the foils must then be moved closer together because the water nip created by surface tension remains close to the point of divergence between the support and trailing surface of the foil. If the foils are brought close together, the span of forming wire between foil supporting surfaces will be shorter, and accordingly, the vertical agitation will be less or at least more frequent and more violent.

SUMMARY OF THE INVENTION

It is an aim of the present invention to provide a blade arrangment which has the advantages of easily replaceable foils which can be made to meet predetermined suction and fabric motion requirements.

A construction in accordance with the present invention includes a drainage device for draining a moving forming fabric, including, in combination, a first leading surface to support the forming fabric, disposed transverse of the direction of travel thereof. A trailing surface is disposed transverse of the direction of travel of the forming fabric downstream from the first leading support surface. A second support surface is adapted to support the forming fabric disposed transverse of the direction of travel thereof and spaced downstream of the trailing surface and forming a gap therebetween. Means are provided for applying suction in the gap. The trailing surface has a depth below the first and second support surfaces and a length whereby the moving fabric is not normally supported by the trailing surface, and the distance between the forming fabric and the trailing surface does not exceed a distance necessary to allow the formation and maintenance of a hydrodynamic nip therebetween upon the application of suction by the suction means which will effectively prevent liquid from flowing between the forming fabric and the trailing surface, thereby effectively limiting the drainage suction to the distance between the hydrodynamic nip and the second support surface upon which the forming fabric is supported. There is also a physical downward pull on the forming fabric at the hydrodynamic nip. Of course, any point on the forming fabric, after it passes the hydrodynamic nip, tends to move upwardly towards the second support surface so that the suction applied at the hydrodynamic nip increases the vertical movement of the forming fabric to thereby obtain the required vertical movement of the forming fabric.

More specifically, it is important that the trailing edge be recessed from the leading support surface such that the surface between the support surface and the trailing surface diverges from the support surface at an angle greater than 5° so that the hydrodynamic nip does not occur in the area of divergence from the support surface as in Wrist-type foils. In the present invention, by varying the depth of the recessed trailing surface and the length of the trailing surface, the hydrodynamic nip location can be predetermined in relation to the speed and flexibility of the forming wire so as to increase or decrease the effective suction area which occurs between the hydrodynamic nip and the succeeding support surface and to better locate the point of pull-down on the forming wire with respect to the forming wire vertical motion.

BRIEF DESCRIPTION OF THE DRAWINGS

Having thus generally described the nature of the invention, it will be described in more detail, with particular reference to the drawings, showing by way of illustration, a preferred embodiment thereof, and in which:

FIG. **1** is a schematic view of a vacuum box with a series of blades spaced apart therein; and

FIG. **2** is an enlarged view of a blade of FIG. **1.**

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, a forming fabric is indicated generally at **10,** while the vacuum box is identified by the numeral **12.** A series of blades **14** extend laterally of the travel of the wire screen but longitudinally of the vacuum box. The blades **14** are supported on the vacuum box in a known manner, for instance, as described in U.S. Pat. No. 3,629,058. For instance, a series of elongated members **28** are welded at each end to the end walls of the vacuum box, and the blades include a half dove-tail shaped rib **30** adapted to fit in a dovetailed groove **32** in member **28.** A wedge (not shown) would be used to fix the dove-tail rib **30** in the groove **32.** Transverse spaced-apart support members (not shown) could be provided under the members **28.** Each blade, as shown in FIG. **2,** has a leading flat support surface **16** and a recessed surface **18.** It is preferable that

the angle of divergence of the intermediate surface **26** between the flat support surface **16** and the recess surface **18** be greater than 5°, which in this case is 90° as shown at **20.** If the angle is less than 5°, then the suction feature of the prior art patents would reduce the effectiveness of the blades in the present invention.

The depth of the recessed surface **18** from the plane flat support surface **16** is identified in FIG. **2** by the reference *x*. On the basis of the present development, this recess has been found to be preferably between the range of 0.005 inches to 0.120 inches with the length of the surface **18** of about 1 to 4 inches. The dewatering length or space between the trailing edge **22** and the leading edge **24** of a downstream blade would be in the range of between 0.25 to 2.00 inches. There would normally be **4** to **9** blades **14** for each vacuum box.

In tests which have been carried out, the proportional length of the recessed portion **18** to the dewatering length was varied and measured relative to a predetermined effective span length. All of the following data relates to vacuum boxes which were operable within the terms of reference of the present invention.

On a Fourdrinier machine using a bronze wire in a 1200–1400 fpm application, a vacuum box having nine foils would have the following criteria:

effective span	2.25"
recess length	1.69"
de-watering length	.56"
recess depth	.030"

In another example, using the same wire on the same machine, seven blades on a vacuum box would have the following criteria:

effective span	3.17"	
recess length	2.54"	
de-watering length	0.63"	
recess depth	.045"	and .060"

In yet another example, with the same wire and machine, a vacuum box with only five blades would have the following criteria:

effective span	5.00"
recess length	4.00"
de-watering length	1.00"
recess depth	.045"

The following Table provides data for a projected operable range of blades:

TABLE

	Embodiment I		Embodiment II		Embodiment III		Embodiment IV	
Effective Span	Length Recess	De-watering Length	Length Recess	De-watering Length	Length Recess	De-watering Length	Length Recess	De-watering Length
1.95"	1.27"	.68"	1.37"	.58"	1.46"	.49"	1.56"	.39"
2.25"	1.46"	.79"	1.57"	.68"	1.69"	.56"	1.80"	.45"
2.65"	1.72"	.93"	1.86"	.79"	1.95"	.74"	2.12"	.53"
3.17"	2.06"	1.11"	2.22"	.95"	2.38"	.79"	2.54"	.63"
3.90"	2.53"	1.37"	2.73"	1.17"	2.92"	.98"	3.12"	.78"
5.00"	3.25"	1.75"	3.50"	1.50"	3.75"	1.25"	4.00"	1.00"

The recess length in Embodiment I is 65% of the effective span, while in Embodiment II, it is 70%. In Embodiment III it is 75%, and in Embodiment IV it is 80%. It would appear that the optimum effect is obtained when the recess length is between 75 and 80% of the effective span.

The depth of the recess is dependent on the type of wire used, the normal speed of the machine, and the nature of furnish. For instance, while using a bronze wire, a recess depth within a range of 0.005 inch to 0.045 inch was found to be operable with the optimum between 0.030 inch and 0.045 inch. However, when using a plastic wire, a range of 0.030 to 0.120 is anticipated to be operable while the optimum range is 0.045 and 0.090.

As the forming fabric **10** passes over the vacuum box **12,** it is supported by the flat surfaces **16** of the blades **14.** However, it is unsupported across the effective span between the succeeding flat surfaces **16** as shown in FIG. **1,** and the forming fabric is actually pulled down at the hydrodynamic nip thereby increasing the vertical motion of the forming fabric as it passes over the support. The shape the forming fabric **10** would normally take is somewhat along the lines as that shown in FIG. **2.** After passing over successive blades, the forming fabic would have the desired vertical motion.

Therefore, the depth of the recess portion **18** of the blade should be such that when the forming wire passes over the recess portion in a deflected manner, such as shown in FIG. **2,** the distance between the wire screen and the recessed portion at the trailing edge would not be great enough to allow water to flow normally and, therefore, there would effectively be little suction in that area of the recess portion **18.** It is desired that the suction only be present between the nip and leading edge of succeeding blades.

I claim:

1. A drainage device for draining a moving forming fabric comprising a vacuum box extending transversely of the direction of travel of the forming fabric, a plurality of drainage blades extending longitudinally on the vacuum box and spaced apart forming a gap therebetween, each blade including a leading support surface for supporting the forming fabric, an intermediate surface diverging from the plane of the support surface at an angle exceeding 5°, and a recessed trailing surface having a depth such that it does not support a span of the moving forming fabric and having a length such that the lowest point of the forming fabric between the leading support surfaces of succeeding blades and the trailing surface is spaced a distance necessary to prevent water from flowing between the forming fabric and the recessed trailing surface such that a hydrodynamic nip is formed between the forming fabric and the trailing surface when vacuum is applied by the vacuum box, thereby effectively limiting the drainage suction to the distance between the nip and a leading edge of a succeeding blade.

2. A drainage device as defined in claim **1,** wherein the angle of divergence of the intermediate surface is 90°.

3. A drainage device as defined in claim 1, wherein the span is between 1.95 inches and 5.00 inches, the gap distance between successive blades is in the range of 0.25 inch to 2.00 inches and the depth of the recess is between 0.005 inch and 0.120 inch with the length of said trailing recess surface being between about 1 inch to 4 inches.

4. A drainage device as defined in claim 3, wherein there are nine blades provided in a vacuum box and the span between blades is 2.25 inches with a recess length of 1.69 inches and a gap distance of 0.56 inch, the depth of the recess being 0.030 inches.

5. A drainage device as defined in claim 3, wherein there are seven blades provided in a vacuum box and the span between blades is 3.17 inches with a recess length of 2.54 inches and a gap distance of 0.63 inches, the depth of the recess being 0.045 inches and 0.060 inches.

6. A drainage device as defined in claim 3, wherein there are five blades provided in a vacuum box and the span between blades is 5.00 inches with a recess length of 4.00 inches and a gap distance of 1.00 inch, the depth of the recess being 0.045 inches.

7. A drainage device as defined in claim 3, wherein the depth of the recess is within a range of 0.030 inches and 0.090 inches.

8. A drainage device as defined in claim 7, wherein the depth of the recess is between 0.045 inches and 0.060 inches.

9. A drainage device for draining a moving forming fabric including, in combination, a first leading surface adapted to support the forming fabric disposed transverse of the direction of travel thereof, a trailing surface disposed transverse of the direction of travel of said forming fabric downstream from said first leading support surface, an intermediate surface provided between the first leading support surface and the trailing surface diverging from the plane of said leading support surface in the direction of said trailing surface at an angle exceeding 5°, a second support surface adapted to support the forming fabric disposed transverse of the direction of travel thereof and spaced downstream of said trailing surface and forming a gap therebetween, means for applying suction in said gap, said trailing surface having a depth below the first and second support surfaces and a length whereby the moving fabric is not normally supported by said trailing surface, the distance between the forming fabric and the trailing surface not exceeding a distance necessary for formation and maintenance of a hydrodynamic nip therebetween upon the application of suction by said means for applying suction which willl effectively prevent liquid from flowing between the forming fabric and the trailing surface thereby effectively limiting the drainage suction to the distance between said nip and said second support surface upon which said forming fabric is supported.

10. A drainage device in accordance with claim 9, in which said first leading support surface, said intermediate surface and said trailing surface provide a first blade.

11. A drainage device in accordance with claim 10, in which a plurality of blades substantially identical to said first blade are provided, and said second support surface is a portion of a second blade of said plurality which trails said first blade in said device.

12. A drainage device in accordance with claim 9, in which said first leading surface and said trailing surface are substantially horizontal flat parallel planes.

13. A drainage device as defined in claim 9, wherein the distance between the first leading surface and a second support surface is between 1.95 inches and 5.00 inches, the distance of the gap is in the range of 0.25 inch to 2.00 inches, the length of the trailing surface is selected within a range between 1.00 inch and 4.00 inches, and the depth of the trailing surface below the first and second support surfaces is in a range of between 0.005 inch and 0.120 inch.

14. A drainage device as defined in claim 13, wherein the depth of the recess is within a range between 0.030 inch and 0.090 inch.

15. A drainage device as defined in claim 14, wherein the depth of the recess is between 0.045 inch and 0.060 inch.

16. A drainage device as defined in claim 11, wherein there are nine blades provided in a vacuum box and the span between blades is 2.25 inches with a recess length of 1.69 inches and a gap distance of 0.56 inch, the depth of the recess being 0.030 inches.

17. A drainage device as defined in claim 11, wherein there are seven blades provided in a vacuum box and the span between blades is 3.17 inches with a recess length of 2.54 inches and a gap distance of 0.63 inches, the depth of the recess being 0.045 inches and 0.060 inches.

18. A drainage device as defined in claim 11, wherein there are five blades provided in a vacuum box and the span between blades is 5.00 inches with a recess length of 4.00 inches and a gap distance of 1.00 inch, the depth of the recess being 0.045 inches.

19. In a drainage device for draining a moving forming fabric which is passed thereover under the influence of suction and having spaced apart forming fabric support surfaces, a blade having a leading surface comprising a forming fabric support surface, said blade having a trailing surface and an intermediate surface between the leading support surface and the trailing surface diverging from the plane of said leading support surface in the direction of said trailing surface at an angle exceeding 5°, said trailing surface having a depth relative to the leading surface and a length whereby the forming fabric is not normally supported by the trailing surface and so that upon the application of suction between said trailing surface and a succeeding forming fabric support surface on the drainage device, liquid drained from said forming fabric will provide a hydrodynamic nip between said forming fabric and said trailing surface, which will effectively prevent liquid from flowing between the forming fabric and the trailing surface thereby effectively limiting the drainage suction to the distance between said hydrodynamic nip and the succeeding support surface of the drainage device.

20. A blade as defined in claim 19, wherein the depth of the trailing surface relative to the leading surface is in a range between 0.005 inch and 0.120 inch and the length of the trailing surface is between 1.00 inch and 4.00 inches.

21. A blade as defined in claim 20, wherein the angle of divergence from the plane of the leading support surface, of the intermediate surface, is 90°.

* * * * *