March 11, 1969 B. A. THORP 3,432,385

WATER EXTRACTION DEVICES

Filed Dec. 15, 1965 Sheet 1 of 2

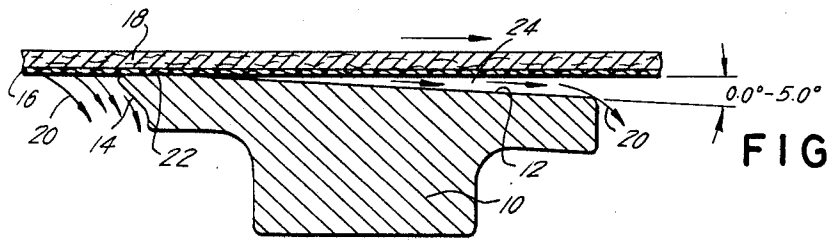


FIG. 1

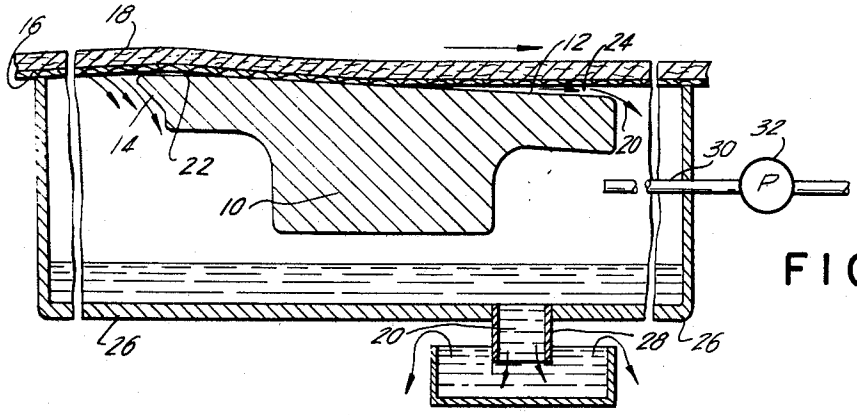


FIG. 2

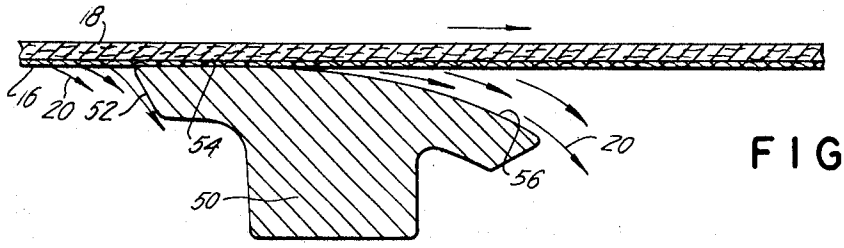


FIG. 3

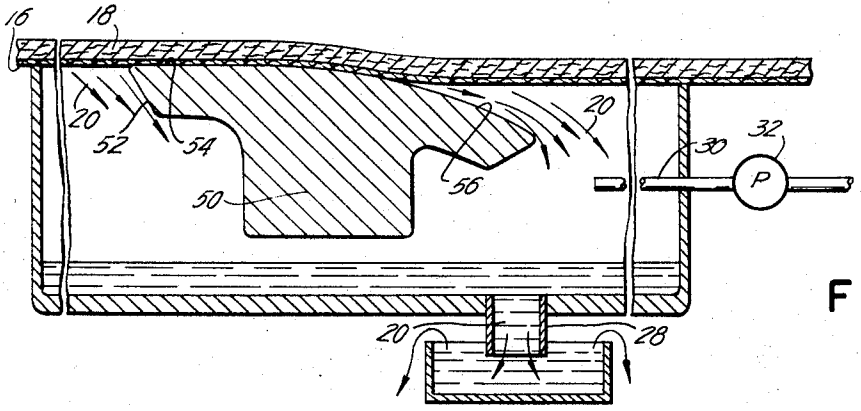


FIG. 4

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WATER EXTRACTION DEVICES

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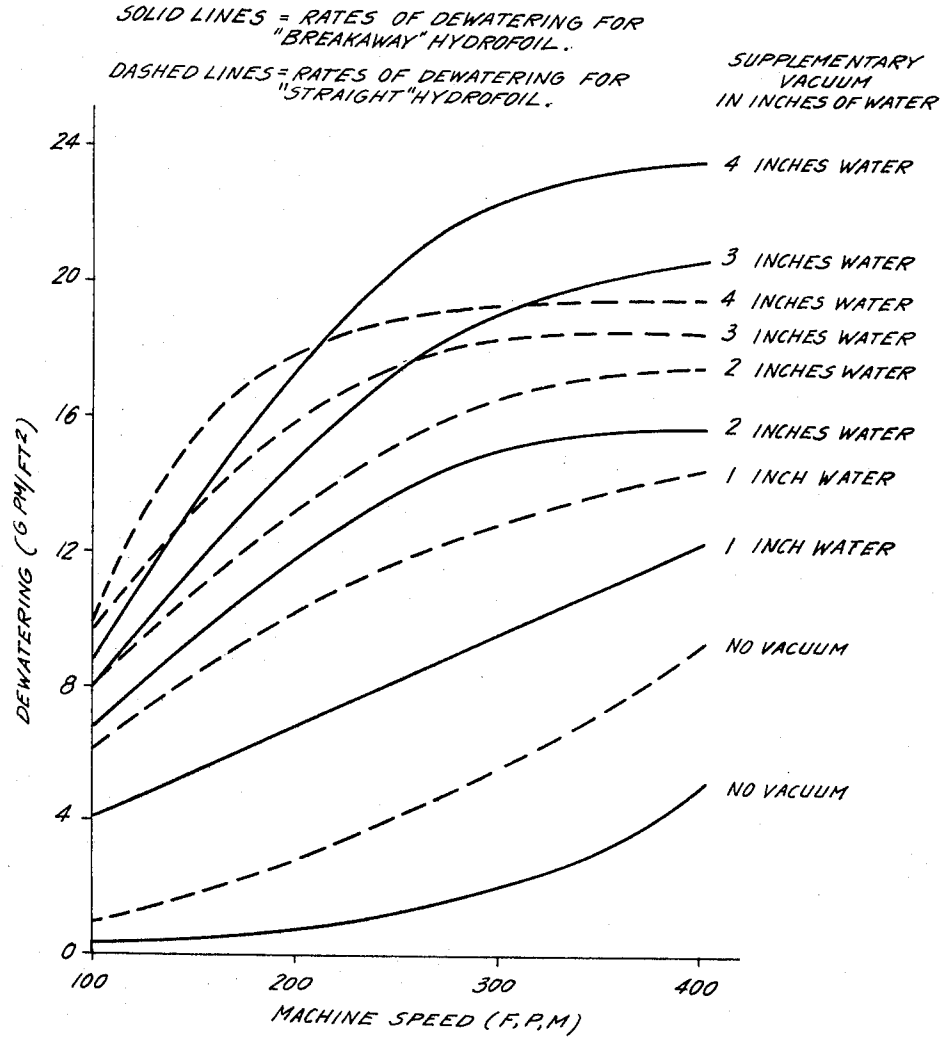


FIG. 5

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WATER EXTRACTION DEVICES

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U.S. Cl. 162—352 10 Claims
Int. Cl. D21f 1/58

ABSTRACT OF THE DISCLOSURE

This invention relates to water extraction devices known as "hydrofoils," useful, for example, in the manufacture of paper. The hydrofoil blades are curved and are mounted on a closed box to which a supplementary vacuum is applied whereby the vacuum, and therefore the rate of water extraction from a paper web, for example, may be selectively varied over a range broader than was previously attainable.

This invention relates to the manufacture and processing of paper and more particularly is concerned with improvements in the water extraction devices known as "hydrofoils" which are used in the forming section of machines on which "paper," meaning pulp, paper, paperboard, or other materials which are paperlike in form, may be made.

A typical continuous papermaking machine on which the invention taught herein may be practiced is the so-called Fourdrinier machine, which usually consists of three sections; a forming section, a press section, and a dryer section. In the forming section, a liquid suspension of fibers, sometimes referred to as "furnish," is flowed onto a forming medium, which is a pervious, endless, belt-like structure made from metal and/or synthetic filaments. The function of the forming medium is to convey the furnish along through the papermaking machine while most of the water is removed from the furnish by the use of water extraction devices, such as hydrofoils, table rolls, and/or suction boxes above which the furnish carrying portion of the forming medium is positioned. The continuous paper web formed thereby is then transferred to the press section where it is passed through a series of nips formed by press rolls, which serves to remove additional water from the web and to compact it. Finally, the web is transferred to the dryer section where it is passed upward and downward over a series of heated dryer rolls or cylinders which are arranged parallel to each other in top and bottom arrays, for the purpose of further reducing its moisture content to the extent desired.

The use of suction boxes as devices for extracting water from the furnish in the forming section of such a papermaking machine is well known in the papermaking art, as is the use of table rolls which, in addition to their use as support means for the forming medium, have a dynamic effect on the removal of water from the furnish by inducing a reduction in ambient pressure in the region where each roll surface diverges from the underside of the forming medium.

In recent years, static devices known as "hydrofoils" have been shown to have certain advantages over other water extraction devices, including efficiency and low cost to install, maintain, and operate, and therefore have gained widespread acceptance. A hydrofoil is a stationary blade-like structure which is positioned beneath the forming medium in supporting relationship thereto. The hydrofoil has a front or "leading" surface which faces toward the direction from which the forming medium moves, which surface is oriented at an acute angle to and with its topmost edge in contact with the undersurface of the forming medium. Frequently hydrofoils have a top surface, the leading edge (the one facing the oncoming forming medium) of which adjoins the top edge of the leading surface; which top surface is in contact substantially throughout with the undersurface of the forming medium. It has been found that incorporation into the hydrofoil structure of such a top surface may not be essential, particularly in "breakaway" or curved structures of the type hereinafter described, so their use is optional. The functions of a top surface include supporting the furnish-laden forming medium, and effecting a seal to prevent the flow of air into the zone of vacuum hereinafter described. This last purpose is particularly important in "straight" hydrofoils as hereinafter described, whether or not such hydrofoils are vacuum augmented.

Finally, hydrofoils have a "trailing" surface which faces in the direction toward which the forming medium is traveling and diverges from the undersurface thereof in the direction of travel. The effect of this diverging trailing surface, acting in concert with the flow of gas and water entrained by the moving forming medium, is to induce a reduction of pressure (or a vacuum) in the zone between the underside of the forming medium and the surface of the trailing edge immediately following the point at which the two diverge, which zone of vacuum may be perfected by the seal which is effected by water coming through the forming medium to the underside thereof between it and the part of the hydrofoil on which it bears. Thus the rate of water extraction effected by a hydrofoil may be shown to be a function of the length of the trailing surface, the speed of the forming medium, the density of the "white water" extracted from the furnish, and the angle between the trailing surface and the forming medium.

U.S. Patent No. 2,928,465 discloses a "straight" hydrofoil structure which is alleged to effect the optimum in water extraction ability. That structure has a flat trailing surface (from which it derives its designation) which diverges from the undersurface of the forming medium at an angle in the range of 0° to 5°. Recently, hydrofoil structures having convex accurate trailing surfaces have been used, but to a more limited extent because of the lower rate of water extraction which they inherently effect.

In utilizing water extraction devices, the considerations which normally govern are maximizing the rates of water extraction and controlling the rates of water extraction. It is usually sought to maximize the rate of water extraction to achieve, as fully as possible, effective utilization of machine time and facilities. However, it is sometimes desirable to operate with water extraction rates less than maximums in deference to other considerations, such as the weight of the paper being formed, forming phenomena, etc. Whatever end is sought, accurate and selective control of the rate of water extraction is also desirable. As a practical matter, such maximization and control of hydrofoils is limited to the degree to which the angle of divergence of the trailing edge may be varied, for the other factors affecting these matters are more or less rigidly circumscribed in given installations. Mechanical variations in the angle of divergence of the trailing surface have proven to be unacceptable, because of the ambient conditions under which the hydrofoil operates, the losses of machine utilization, and the impossibility of effecting accurate adjustments.

U.S. Patent No. 2,928,465 discloses straight hydrofoils positioned atop suction boxes whereby may be introduced vacuum supplementary to that which is dynamically induced by the concerted interaction of the moving forming medium and the flat trailing surface of the hydrofoil. However, it has been found that such an arrangement is of limited effectiveness in terms of the range of the rate

of water extraction which may be effected thereby. For a given speed of the forming medium, the maximum rate of water extraction of a straight hydrofoil unaided by vacuum may be shown to increase as the angle between the trailing surface of the hydrofoil and the undersurface of the forming medium, measured when it is at rest, is increased from 0°. The maximum rate of water extraction will always occur when the angle is somewhere in the range of 0°–5°. This range of angles is so small that when a supplementary vacuum is added to that already created by the hydrofoil itself, the furnish-laden forming medium will be pulled down closer to the surface of the trailing portion of the hydrofoil. This is particularly true where hydrofoils are used in conjunction with all-synthetic forming media of the type disclosed in Holden U.S. Patent No. 2,903,021, which are inherently more supple than forming media made from metallic wires.

At least four adverse effects result: (1) the length of the "nip," or area of contact between the hydrofoil and the underside of the forming medium, is decreased since the forming medium no longer bears on the top surface of the hydrofoil but instead is raised therefrom as it is pulled closer to the trailing surface, causing the effective nip area to be reduced to the line of juncture of the top and trailing surfaces, and this in turn causes the vacuum "seal" effected by the nip to be significantly less effective and, therefore, the rate of water removal to be reduced, (2) the dynamically induced vacuum is diminished or even eliminated as the angle of divergence between the trailing surface and the forming medium is reduced, (3) water removal is significantly restricted because of a resulting reduction of area in the water receiving void between the trailing surface and the forming medium, and (4) the effective area over which the supplementary vacuum may operate is significantly reduced because the forming medium tends to hug a greater portion of the surface of the hydrofoil.

One solution which has been proposed for this problem is to extend the flat trailing surface of the straight hydrofoil, but it has been found that while this may tend to restore the induced vacuum action, there are still prohibitively significant reductions in the nip area, the area of the water receiving void between the hydrofoil and the forming medium, and the effective area of application of the supplementary vacuum. This solution presents another drawback in that the added space occupied by the extended trailing surface significantly reduces the number of hydrofoil units which may be positioned along a given length of travel of the forming medium, since adequate room for water shed between foils must be preserved, thereby materially and adversely affecting the efficiency of operation. On the one hand, these remaining objections to increasing the length of the trailing surface cannot be avoided to any significant extent by increasing the angle at which it diverges from the undersurface of the forming medium, because the dynamic effect of the hydrofoil has been shown to diminish rapidly as the angle is increased beyond 5°, thereby negating optimum utilization of the dynamic properties inherent in the hydrofoil. On the other hand, without increasing the length of the straight trailing edge, the angle must be increased far beyond 5° if the adverse affects of "pull down" of the furnish-laden forming medium are to be avoided.

Accordingly, it is an object of this invention to provide a means whereby the rate of water extraction of a hydrofoil device may be increased beyond the rate presently available.

It is yet another object of this invention to provide a means whereby the range of rates of water extraction which may be achieved with a single design of hydrofoil may be increased.

Yet another object of this invention is to provide a means whereby a greater number of hydrofoil devices may be accommodated in a given length of forming section in a papermaking machine.

Still another object of this invention is to provide a means whereby the rate of water extraction in the forming section of a papermaking machine may be varied over a larger portion of the whole forming section.

That these and other objectives which may be achieved through use of this invention will be readily apparent to those skilled in the cognizant arts from the description which follows, and from the following illustrations in which:

FIG. 1 is a cross-sectional representation of a straight hydrofoil in operation on a papermaking machine.

FIG. 2 is a cross-sectional representation of a straight hydrofoil in operation on a papermaking machine with a supplementary vacuum applied,

FIG. 3 is a cross-sectional representation of this invention in operation on a papermaking machine,

FIG. 4 is a cross-sectional representation of the embodiment of this invention illustrated in FIG. 3 with supplementary vacuum applied,

FIG. 5 is a graph of comparating results achieved utilizing a straight hydrofoil such as that illustrated in FIGS. 1 and 2 with those achieved utilizing a hydrofoil device such as that illustrated in FIGS. 3 and 4.

Referring first to FIG. 1, illustrated therein is a "straight" hydrofoil **10**, so-called because of its straight (or flat) trailing surface **12**. This hydrofoil has a leading surface **14** which is oriented at an acute angle with respect to the forming medium **16** which conveys liquid laden furnish **18** through the forming section of a papermaking machine. The leading edge **14**, facing the direction from which the furnish-laden forming medium **16** is coming, serves to "doctor" water **20** from the underside of the forming medium.

Interposed between the leading surface **14** and the trailing surface **12** there is optionally incorporated a top surface **22**, which is substantially flat and in contacting and supporting relationship substantially throughout with the underside of the forming medium **16**. This contact area is sometimes referred to as a "nip." Although optional, its use may be desirable since it effects a broadened zone through which water coming through the forming medium **16** from the furnish **18** that is not doctored off by the leading edge **14** but is carried into the nip, or coming through the forming medium while it is in the nip area, forms a lubricated seal which tends to restrict air from passing therethrough to relieve the partial vacuum created past the nip along the path of travel of the forming medium as hereinafter described.

Immediately following the top surface **22** along the path of travel of the forming medium **16** is a trailing surface **12** which is typically illustrated as diverging from the plane of the forming medium **16** by an angle of 0°–5°, this being the range of divergent angles over which the maximum rate of water extraction may be shown to occur with a straight hydrofoil for the range of machine speeds now in common use. The effect of this diverging trailing surface **12**, acting in concert with the entrainment effect of the moving forming medium **16** which tends to move gas and liquid from the interstice between the trailing surface **12** and the forming medium **16**, is to set up an interstitial zone **24** of reduced pressure, or partial vacuum, the effect of which is to raise the rate at which water is extracted from the furnish **18** through the forming medium **16**.

It will be apparent that with devices of the type illustrated in FIG. 1, the rate of water extraction effected thereby may be varied in several fashions. An increase in speed of the forming medium will cause it to increase, but the speed at which the formed web of paper may be conveyed through the paper machine usually is limited by other factors, such as the thermal capacity of the dryer section. The zone of vacuum **24** may be increased by extending the length of the trailing surface **12**, but this increases the amount of space occupied by the unit and, more objectionally, only achieves an increase in the rate,

but does not permit selective variation of the rate, downward as well as upward. The angle of divergence of the trailing edge **12** may be varied and, since this angle is related to the rate of extraction, the rate may thereby be varied upward as well as downward, but such mechanical variations of angles are undesirable due to the difficulty of making minute angular changes accurately, particularly to a uniform degree over the long distances that single hydrofoils extend across papermaking machines that may be in excess of 200" or even 300" in width. Furthermore, such mechanical adjustments may be made under the most adverse conditions of fouling with furnish discharged through the forming medium, and with substantial losses in machine time.

It is apparent then that some simpler and more easily operable means to vary the rate of water extraction is needed.

One solution which has been proposed is to combine a straight hydrofoil with a supplementary vacuum means. Such apparatus, and the difficulties attendant thereto which make this an undesirable solution are illustrated in FIG. 2. In FIG. 2 is shown a hydrofoil **1** which has all the same elements as the hydrofoil **10** which was illustrated in FIG. 1. However in FIG. 2, the hydrofoil **10** is affixed to the top of a vacuum box **26**, in which vacuum supplementary to that induced by the concerted action of the forming medium and the hydrofoil is introduced. Such supplementary vacuum may be effected by a variety of well-known means, including a so-called "drop leg" **28**, which is a standpipe projecting downward from the bottom of the vacuum box **26** wherein the weight of a substantially continuous column of effluent water **20** acts like a downward stroking piston to induce a partial vacuum in the box **26**. Supplementary vacuum might also be induced in the box **26** by means of a vacuum line **30** terminating therein, which is connected to some vacuum producing source **32**, such as a pump.

The application of such a vacuum will cause the rate of water extracted to increase, but it also produces other effects which are objectionable in the operation of the straight hydrofoils. As shown in FIG. 2, the effect of the vacuum acting on the forming medium **16** is to pull the forming medium down along a substantial portion of the leading portion of the trailing surface **12**. This, in turn causes the forming medium to raise up and away from contact with the top surface **22**, since the forming medium must bridge up over the line of intersection of the flat top surface **22** with the flat trailing surface **12**, thereby reducing the nip area and so disrupting, or at least diminishing, the vacuum seal. Furthermore, the operative length of the trailing surface **12** as a vacuum inducing means is effectively reduced with corresponding reduction in the amount of vacuum dynamically induced thereby. Also, the area of the interstice between the trailing surface **12** and the underside of the forming medium **16** is reduced, thereby reducing the amount of effluent water from the furnish that can be accommodated. Finally, the effective area of the undersurface of the forming medium **16** over which the supplementary vacuum may operate is significantly reduced.

Adverse effects of supplementing the vacuum induced by a hydrofoil device with vacuum from external sources may be substantially avoided through use of this invention, one embodiment of which is illustrated in FIG. 3. FIG. 3 illustrates a so-called "breakaway" or curved foil **50**, which also has an acute angled leading surface **52** and a flat top surface **54**, both of which are analogous in design and function to the corresponding leading surface **14** and top surface **22** respectively, shown in FIG. 1.

In the embodiment of this invention illustrated in FIG. 3, however, the trailing surface **56** is not straight like the trailing surface **12** of the device illustrated in FIG. 1, but, instead, is curved. The curvature of this surface may be truly circular; that is, in cross section described by an arc swing about a point, or it may be of increasing or decreasing radius of curvature moving away from its leading edge in the direction of the path of travel of the forming medium. The exact type of curvature may be varied according to the range of rates of extraction desired and the desired ratio of hydrofoil induced to supplementary vacuum. For example, a curvature of increasing radius will produce results more nearly like those realized with a flat trailing surface, than will a curvature of uniform radius.

The advantageous results, compared to those demonstrated in FIG. 2, which may be achieved through use of the principles of this invention are illustrated in FIG. 4. In FIG. 4 is shown the embodiment of this invention which was illustrated in FIG. 3, in combination with a supplementary vacuum means like that illustrated in FIG. 2. However, as shown in FIG 4, the effect of pull-down of the furnish-laden forming medium by the supplemental vacuum is significantly different when a breakaway foil is used than when a hydrofoil having a straight trailing surface is used. The vacuum seal is preserved throughout the region of the top surface **54**. The effective reduction of area of the trailing surface **56** due to the forming fabric following its contour is significantly reduced. The water receiving interstice area between the trailing surface **56** and the undersurface of the forming medium **16** not only is not reduced, but actually may be increased. The effective area of the forming medium over which the supplementary vacuum may operate is only slightly reduced making for a more uniform vacuum profile down the forming medium in the direction of its travel as well as promoting the efficiency of its operation. In addition, the ultimate degree of divergence of the trailing surface **56** is such that a substantially greater number of hydrofoil units may be accommodated in a given length of the forming medium.

It will be apparent that in addition to supplementary vacuum, supplementary pressure might also be advantageously introduced, for example to offset the dynamic vacuum producing characteristics of a hydrofoil in a region where it is desired to restrict the rate of water extraction in deference to other considerations such as sheet formation. The use of pressure in this invention is extraction achievable thereby. In this connection, it another feature of the broadened range of controlled water should be understood that herein vacuum is indicated in plus inches of water, and pressure is indicated in minus inches of water.

It should also be understood that although the description heretofore set forth has been in terms of a hydrofoil with supplementary vacuum, it is within the contemplation of this invention that more than one hydrofoil might be used with a common supplementary vacuum means, as by positioning several hydrofoils atop a single vacuum box, or that one or more hydrofoils might be used with each of several vacuum means which are in a sequential relationship.

It should also be noted that while this invention has been described in connection with a vacuum box as a supplementary pressure varrying means, other devices similar in result might also be utilized. Thus, a system of holes through the trailing surface itself and connected to a vacuum conduit supplementary to or even within the hydrofoil structure in one example of an alternative pressure varying means which might be advantageously used.

FIG. 5 illustrates, in graphic form, the significant differences between the ranges and degrees of control of rate of water removal which were found to be possible in an actual application of this invention. FIG. 5 is a group of plots of rates of water removal in gallons per minute per square foot of area of forming medium, plotted against forming medium (machine) speed in feet per minute, for a straight hydrofoil and for a breakaway hydrofoil embodying the principles of this invention. The furnish used was 80 lbs. per 3000 sq. ft.

bleached kraft with a headbox freeness of 550 cs. The straight hydrofoil used had a leading surface oriented at 45° to the top surface. The top surface was flat, 1/4" wide. The trailing surface was flat, 1 3/4" wide, and diverged from the plane of the top surface at 2 1/4°. The breakaway hydrofoil that was used had a leading surface which was oriented at 60° to the top surface, a top surface which was flat and 1/2" wide, and a trailing surface which was 1 1/32" long, of uniform curvature with a 2 1/16" radius. The comparative results achieved are plotted in FIG. 5 with supplemental vacuum of 0–4 inches of water; the plots for the breakaway hydrofoil are shown in solid lines; those for the straight hydrofoil are shown in dashed lines.

It will be apparent that the range of rates of water extraction is broader, the degree of control of rate of extraction is better, and a higher maximum and a lower minimum rate of extraction is attainable, through the use of a vacuum supplemented breakaway hydrofoil, utilizing the principles of this invention, then are those attainable with the straight hydrofoil, even when vacuum augmented, which has heretofore been used.

It should be clearly understood that there is a substantial distinction between the concept of a vacuum means, such as a box as herein described in connection with hydrofoil devices, and a suction box the use of which is well-known in the papermaking art (e.g. see Pulp and Paper Manufacture, vol. 3, page 125 et seq., McGraw-Hill Book Company, Inc., 1953). Suction boxes are operated with a vacuum of 4 to 10 inches of mercury, which is the equivalent of about 48 to 120 inches of water. Such high vacuums are too high to be applied to the furnish in the early stages of forming at which hydrofoils are employed. If it were attempted to use suction boxes in the locations herein contemplated, much of the furnish would be drawn completely through the forming medium, and, in addition, premature formation of a layer immediately adjacent to the upper surface of the forming medium would be effected, thereby actually inhibiting further water extraction. In addition, the added load introduced by the high vacuum in suction boxes necessitates having either a sheet-like perforated top, or grid bars which are closely spaced together. In either case, the more frequent and greater proportion of support which is required to support the additionally loaded forming medium effects frequent and more sustained interruption in the water extraction process at any given point on the forming medium, and, by well-known inertial phenomena, this "starting" and "stopping" of the drainage process may tend to reduce the total amount of water extraction which actually takes place. Furthermore, suction box vacuums are so high that any dynamically induced vacuum added thereto by a hydrofoil, which normally is no more than a few inches of water, would be comparatively inconsequential. Thus, it will be apparent that, for example, the use of grid bars having curved tops as suction box covers in order to accommodate the pull-down of the forming medium due to the extremely high vacuum involved, thereby reducing wear on the forming medium and drag, is not germane to the invention herein disclosed.

It is to be understood that the terms and expressions used herein and the embodiments which have been illustrated are by way of illustration and not of limitation, and that numerous other embodiments of the invention herein described may be utilized by those skilled in the cognizant arts without departing significantly from the scope and spirit of this invention.

I claim:

1. In apparatus for the manufacture of paper, or the like, having a belt-like forming medium, appartus for extracting water from the furnish being transported by said forming medium comprising, in combination, a curved hydrofoil blade and a supplementary pressure varying means,

said hydrofoil blade comprising a leading surface and trailing surface,

said leading surface diverging from the undersurface of said forming medium at an acute angle thereto in the direction of travel of said forming medium, the upper edge of said leading surface being substantially totally in contact with the undersurface of said forming medium is in motion,

said trailing surface having its leading edge substantially totally in contact with the undersurface of said forming medium when said medium is in motion, said trailing surface diverging from the undersurface of said forming medium by increasing increments of distance at sequential locations in the direction of the path of travel of said forming medium,

said pressure varying means communicating externally of said hydrofoil with the mass of gas beneath said forming medium in the region of said hydrofoil, whereby changes in pressure in the zone between said trailing surface and the underside of said forming medium may be effected.

2. The apparatus described in claim 1 wherein said pressure varying means is a vacuum producing device.

3. The apparatus described in claim 2 wherein said trailing surface is circular along a cross-section taken in the direction of travel of said forming medium.

4. The apparatus described in claim 2 having an elongated nip surface interposed between said leading surface and said trailing surface in contact substantially totally throughout with the undersurface of said forming medium and having one long edge thereof contiguous with the top edge of said leading surface and one long edge thereof contiguous with the leading edge of said trailing surface.

5. The apparatus described in claim 3 having an elongated nip surface interposed between said leading surface and said trailing surface in contact substantially totally throughout with the undersurface of said forming medium and having one long edge thereof contiguous with the top edge of said leading surface and one long edge thereof contiguous with the leading edge of said trailing surface.

6. The apparatus described in claim 4 wherein said pressure varying means comprises an enclosure, at least a portion of the top of which is open to the mass of gas beneath said forming medium and is in supporting relationship to said hydrofoil.

7. The apparatus described in claim 5 wherein said pressure varying means comprises an enclosure, at least a portion of the top of which is open to the mass of gas beneath said forming medium and is in supporting relationship to said hydrofoil.

8. The apparatus described in claim 6 wherein the vacuum induced by said vacuum means in the zone between said trailing surface of said hydrofoil and said undersurface of said forming medium is in the range of zero to plus 15 inches of water.

9. The apparatus described in claim 7 wherein the vacuum induced by said vacuum means in the zone between said trailing surface of said hydrofoil and said undersurface of said forming medium is in the range of zero to plus 15 inches of water.

10. In a fourdrinier papermaking machine having a belt-like forming medium, apparatus for extracting water from the furnish being transported by said forming medium comprising a multiplicity of curved hydrofoils affixed to the top of an enclosure at least a portion of the top of which is exposed to the mass of gas beneath said forming medium in the region of said hydrofoils, and means for controllably varying the pressure within said enclosure externally of said hydrofoils in the range of vacuum of minus 5 to plus 25 inches of water,

said hydrofoils being oriented substantially at right angles to the direction of travel of said forming medium,

each of said hydrofoils comprising a leading surface, a nip surface, and a trailing surface,

said leading surface of each such hydrofoil oriented at an acute angle to the undersurface of said forming medium in the direction of travel of said medium with the top edge of each such leading edge contiguous with the leading edge of said nip surface,

the nip surface of each such hydrofoil being substantially totally in contracting relationship with the underside of said forming medium, and

the trailing surface of each such hydrofoil being arcuate and diverging from the undersurface of said forming medium in the direction of travel of said medium when said medium is in motion and having its leading edge contiguous with the trailing edge of said nip surface.

References Cited

UNITED STATES PATENTS

3,239,409 4/1966 Knowles ---------- 162—352

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U.S. Cl. X.R.

162—297, 351

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,432,385 March 11, 1969

Benjamin Adelbert Thorp

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

Column 5, line 22, "1" should read -- 10 --. Column 7, line 71, "appartus" should read -- apparatus --. Column 8, line 9, after "medium" insert -- when said forming medium --. Column 9, line 13, "contracting" should read -- contacting --.

Signed and sealed this 21st day of April 1970.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents