

April 10, 1973

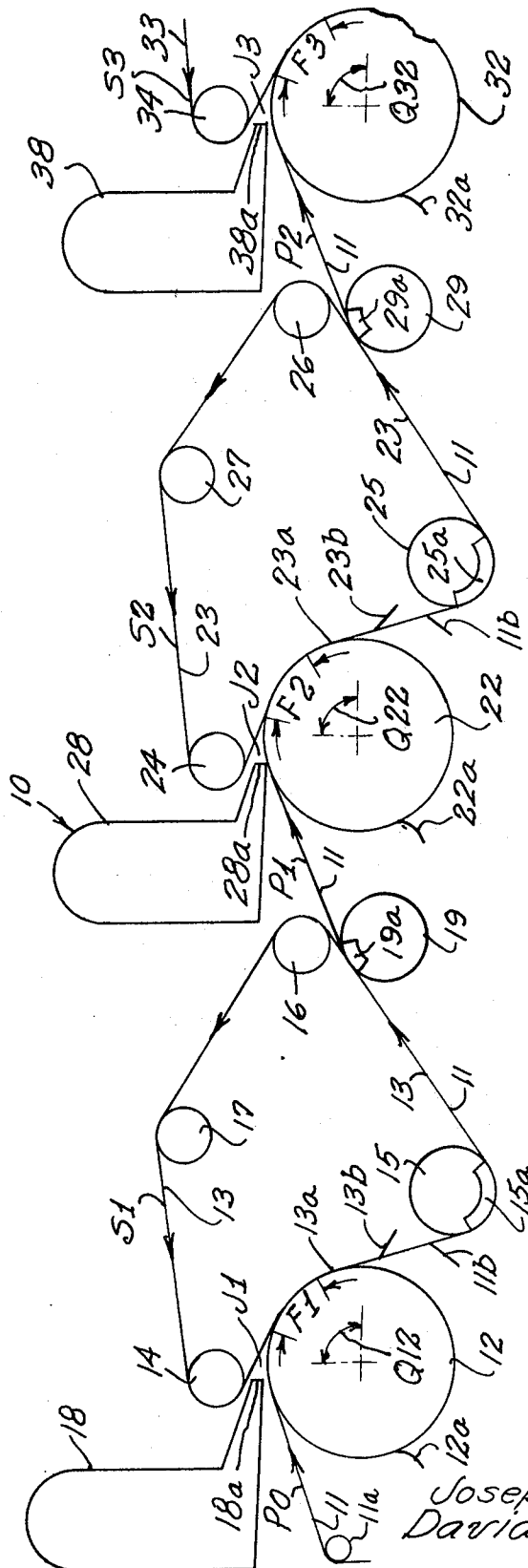
J. D. PARKER ET AL
TWIN-WIRE WEB FORMING SYSTEM WITH DEWATERING BY
CENTRIFUGAL FORCES

3,726,758

Filed July 8, 1971

6 Sheets-Sheet 1

Fig. 1



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J. D. PARKER ET AL **3,7**
TWIN-WIRE WEB FORMING SYSTEM WITH DEWATERING BY
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FIG-3

This diagram illustrates a mechanical assembly in cross-section. The primary components include:

- A large circular body labeled **52**, which contains internal radial features **F.5** and **Q52**. Points **A** and **B** are marked on its upper circumference.
- An L-shaped structural member at the top left, featuring a vertical section **58** and a horizontal base **59a**.
- A curved surface or track labeled **53** positioned above the main body **52**. This surface has several segments labeled **53a**, **53b**, and **53c**.
- A small circular feature **54** with a central crosshair, located near the top center. Its lower portion is labeled **54a**.
- A horizontal reference line or surface labeled **55** intersecting the main body.
- A series of angled surfaces and joints forming a support structure, including elements labeled **71**, **P3**, **11**, **11a**, **52a**, **52b**, **11b**, **55a**, **55b**, and **J5**.

The diagram uses various hatching patterns to distinguish different materials or sections of the assembly.

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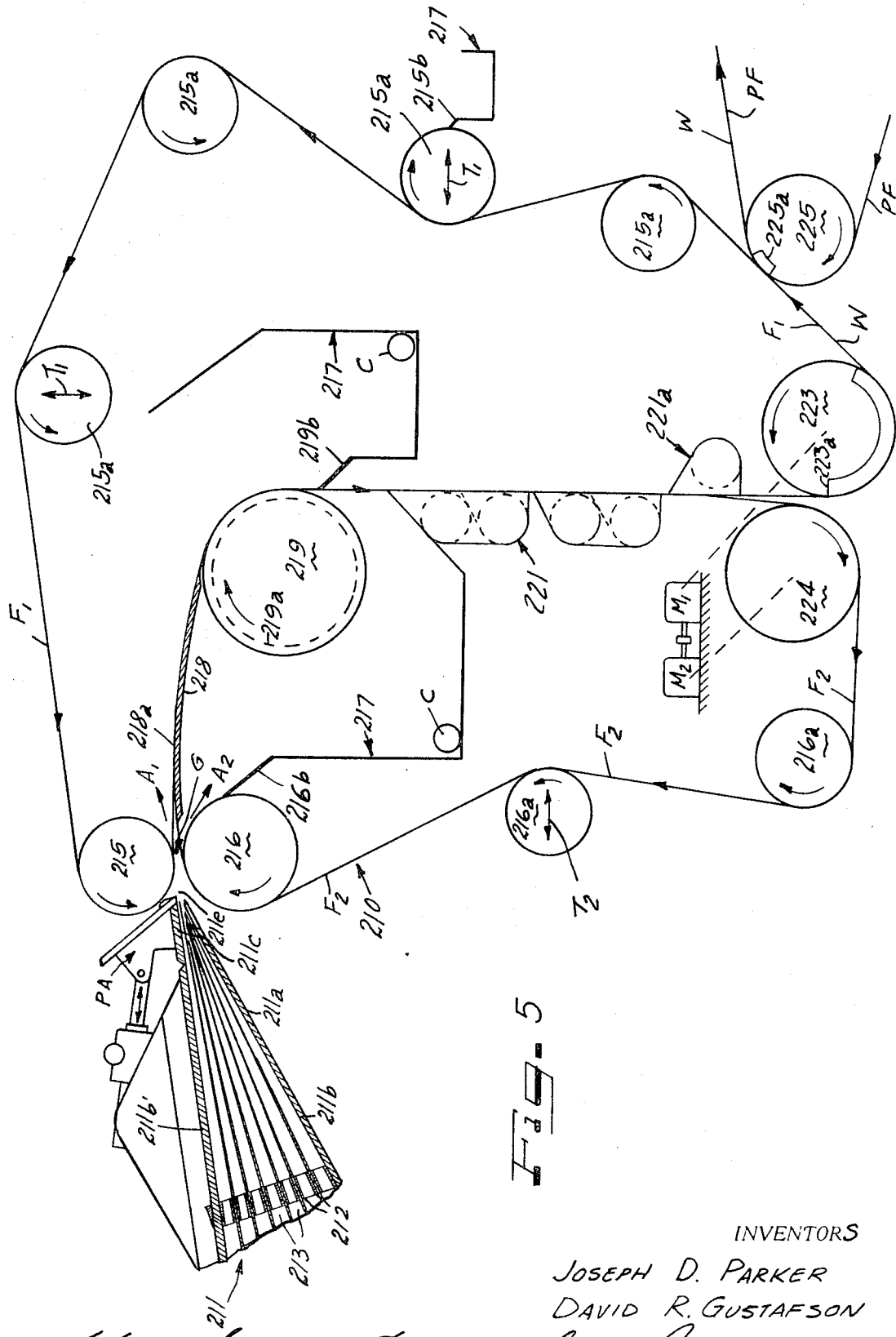


FIG. 5

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Fig. 6

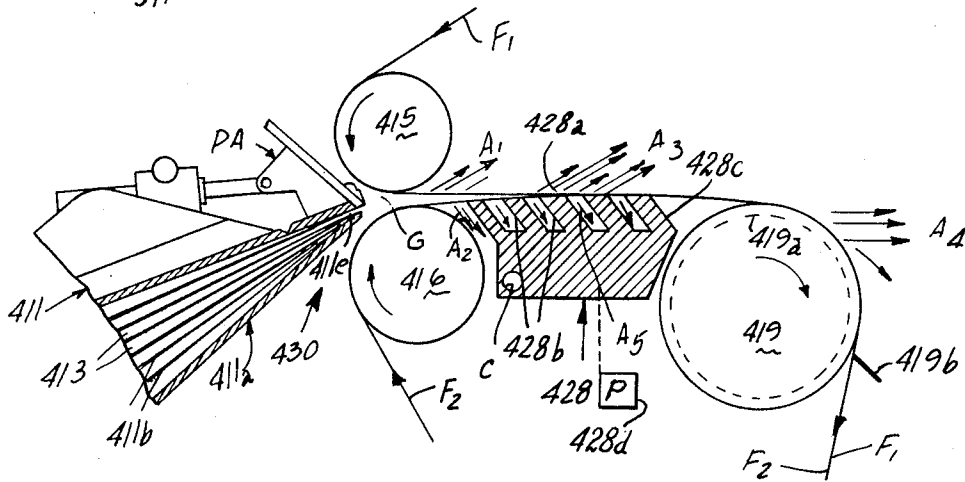
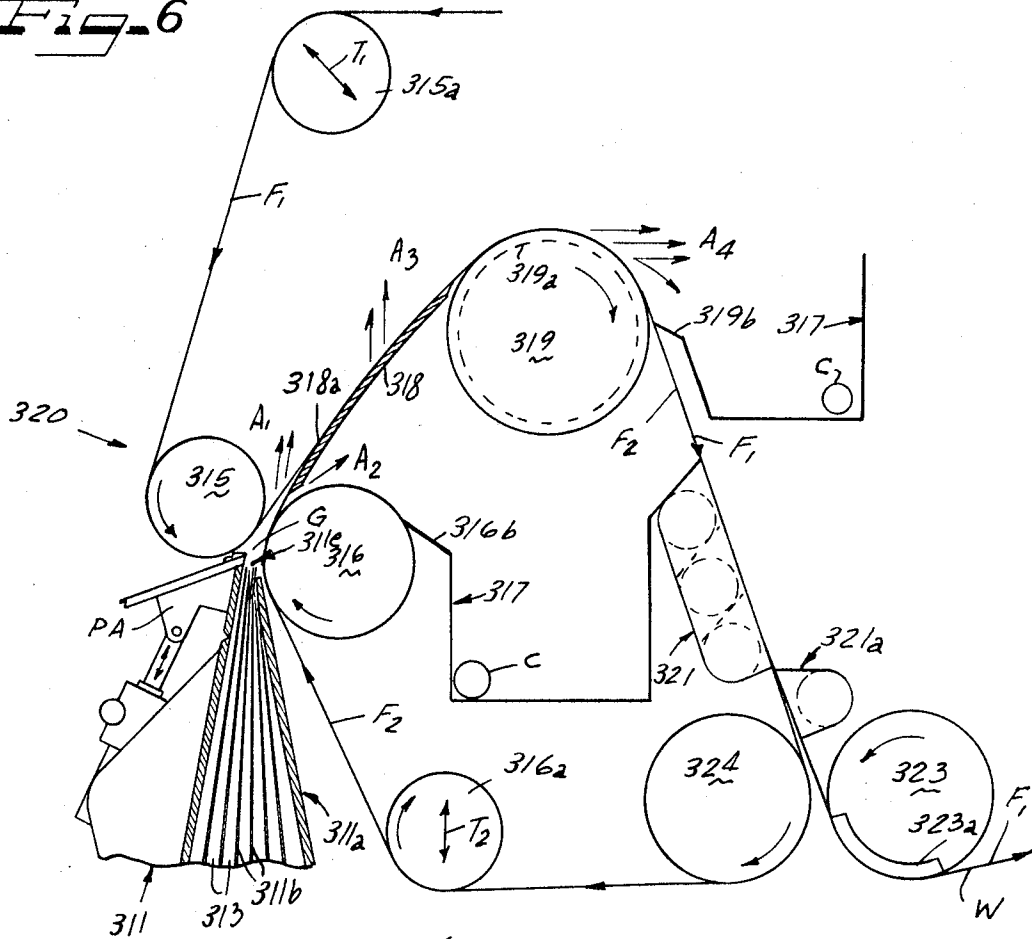


Fig. 7

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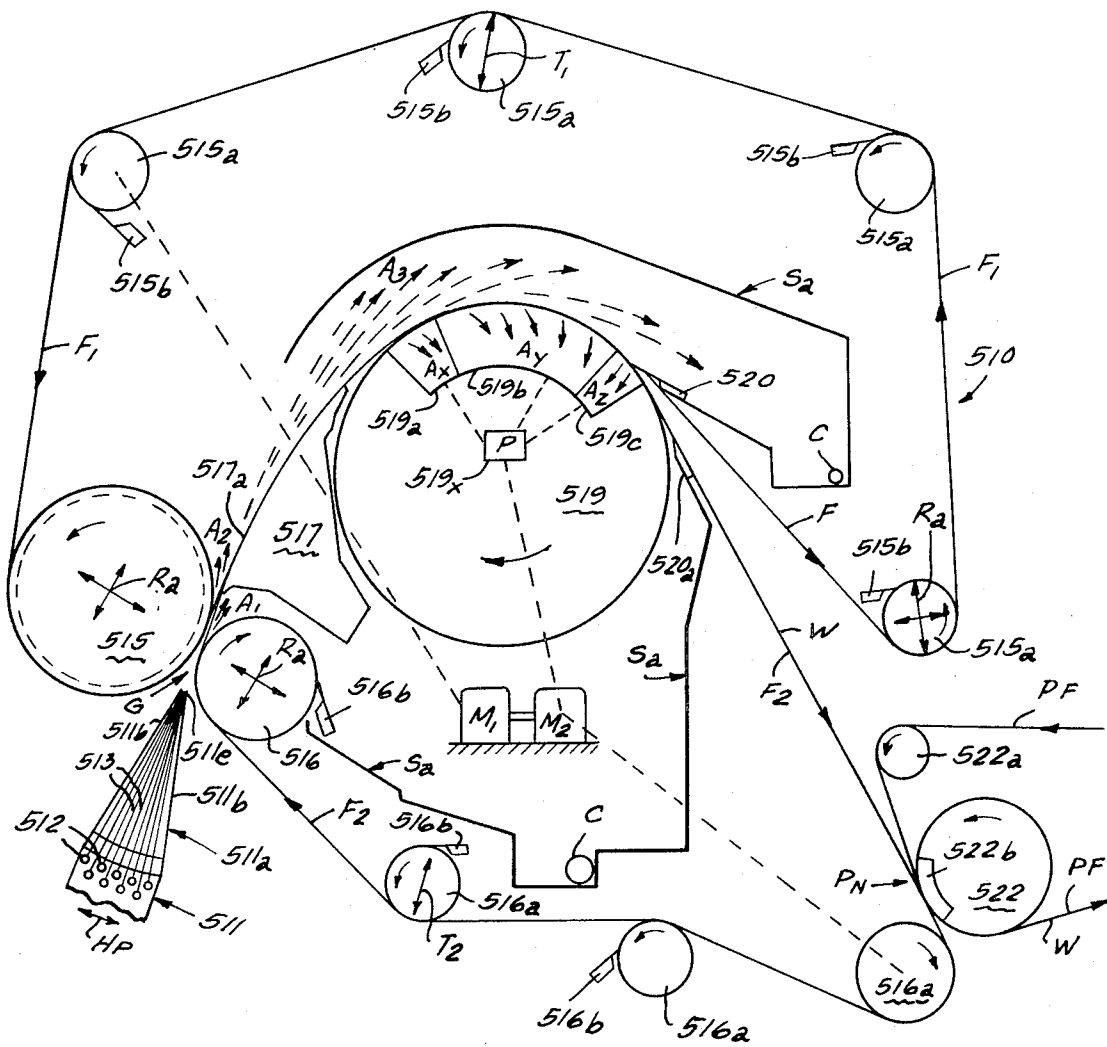
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Fig. 8



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TWIN-WIRE WEB FORMING SYSTEM WITH DEWATERING BY CENTRIFUGAL FORCES

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Continuation-in-part of abandoned applications Ser. No. 792,713, Jan. 21, 1969, and Ser. No. 795,954, Feb. 3, 1969. This application July 8, 1971, Ser. No. 160,879 Int. Cl. D21f 1/36

U.S. Cl. 162—299

23 Claims

ABSTRACT OF THE DISCLOSURE

A twin-wire web making system for use in forming multi-ply or single-ply webs wherein a web stock is discharged into a nip between opposed forming wire runs arranged to converge with one another over guide elements. In one embodiment a plurality of individual forming sequences are associated with a main forming wire for receiving successive plies and merging the same together at each sequence. In another embodiment a single forming sequence is associated with a pick-up felt for removal of the ply from the forming sequence. At each sequence a head box means discharges web stock between twin wires supported by spaced breast rolls defining the nip therebetween and the wires gradually converge into general parallelism over curved guides by wrapping a portion of their surfaces so as to centrifugally dewater the stock sandwiched between the wires. In one aspect of the invention, a stationary curved surface and a rotary cylinder are positioned on the same side of the wires to guide the wires into general parallelism. The stationary surface and the roll combine to define a bi-radii path of wire travel having a first radius of curvature larger than the second radius of curvature. The stationary surface is water impermeable or permeable and includes surfaces having a decreasing radius of curvature in the direction of wire travel. The rotary cylinder includes solid rolls, open rolls and suction rolls. The head box means includes structures containing a plurality of flexible trailing elements therein defining therebetween channels converging in the direction of the nip for producing a stream having a relatively low degree of turbulence and a relatively high degree of dispersion.

CROSS-REFERENCE TO RELATED APPLICATIONS

This is a continuation-in-part application of our co-pending U.S. Ser. Nos. 792,713, filed Jan. 21, 1969, now abandoned, and Ser. No. 795,954, filed Feb. 3, 1969, now abandoned.

BACKGROUND OF THE INVENTION

Field of the invention

The invention relates to fibrous web formation and more particularly to improved apparatus, systems and processes for forming fibrous webs from dilute aqueous suspensions thereof.

Prior art

In relatively recent years the art of web making, particularly paper making, has undergone a number of significant advances in the field of web formation using two opposed forming wire runs for web formation therebetween is contrasted to the heretofore more conventional Fourdrinier-type web making machines employing only a single forming wire. Although such twin wire forming machines have met with limited commercial success, these machines are still in the stage of being improved and various aspects of the operation thereof and the resulting quality of web may leave something to be desired, at least in certain specific instances. For example, as the speed of

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the web making machine is increased, operational difficulties are often encountered in connection with deposition of certain types of stock requiring rather high dilution. The problems encountered are not limited to difficulties in control of water movement (with resulting "rolling" and/or "streaking") but include difficulties of web-sensitivity in some speeds, premature wear of various components, control of pressure applied on the new web, etc. Essentially, the instant invention provides a new and unique forming arrangement which accommodates higher machinery speeds as well as improved quality web so-made.

SUMMARY OF THE INVENTION

The invention generally comprises a forming machine and system including a head box means for providing a ribbon-thin jet stream of web stock in a given direction (horizontal or vertical); two endless loop forming wires arranged to travel in the given direction so as to define a forming zone; a breast roll positioned within each of the looped wires to define a nip therebetween for receiving the stock and curved guide elements positioned downstream of the breast rolls and within the loop of one of the wires to dewater the stock sandwiched between the wires.

In one embodiment, a main forming wire is guided through a plurality of sequences, each sequence having an individual head box means and an auxiliary wire converging with the main wire over curved guide elements so as to dewater the ply formed in that sequence and merge it with preceding plies. In one specific form of this embodiment, the guide elements comprise a large diameter roll, which can be perforated or imperforated, positioned within the loop of the main wire and having its outer surface partially wrapped by the traveling wires so as to centrifugally dewater the stock between the wires. In another specific form of this embodiment, the guide elements comprise a stationary (perforated or unperforated) curved surface followed by a roll, both positioned within the loop of the main wire so as to define a continuous bi-radii curved path of travel having a first radius of curvature larger than the second radius of curvature. A portion of the outer surfaces of the stationary surface and the roll is wrapped by the wires to centrifugally dewater the sandwiched stock. The stationary surface has a constant radius of curvature or a decreasing radius of curvature in the direction of wire travel.

In another embodiment of the invention, a pair of forming wires are guided through an individual sequence having a head box means and means gradually converging the wires into general parallelism over curved guide elements to centrifugally dewater the stock between the wires. A specific form of the head box means includes walls converging toward the outlet opening thereof and a plurality of flexible trailing elements within the head box slice chamber converging toward the opening for guiding aqueous stock as a ribbon-thin jet stream having a relatively low degree of turbulence and a relatively high degree of dispersion into the nip between the wires. A specific form of curved guide elements comprise a stationary curved surface followed by a cylindrical roll, both positioned within the loop of one of the wires for guiding the wires through a change of travel direction to centrifugally dewater the stock between the wires. The stationary surface is solid or formed of a plurality of thin edges, the longitudinal contour of which define the desired curves. The cylindrical roll is a relatively large diameter dewatering roll (open, suction, grooved, drilled, etc.). Couch and turning rolls are positioned within the forming run for separating the web from one of the wires and guiding the web-carrying wire to a pick-up station for transferring the web from the forming zone. In a specific arrange-

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ment, both wires wrap a portion of the couch roll to insure that the web remains in contact with the desired wire through a change of wire travel direction.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an essentially schematic elevational view showing a portion of a web forming machine composed of a plurality of sequences embodying the instant invention;

FIG. 2 is an essentially schematic elevational somewhat enlarged view of an individual sequence as the type shown in FIG. 1;

FIG. 3 is an essentially schematic elevational somewhat enlarged view of another embodiment of the individual sequence shown in FIG. 2;

FIG. 4 is an essentially schematic elevational view showing a portion of a web forming machine somewhat similar to the type shown in FIG. 1 but utilizing the individual sequences shown in FIG. 3;

FIG. 5 is an essentially schematic elevational view illustrating a further embodiment of the invention;

FIG. 6 is an essentially schematic elevational partial view of a modified form of the embodiment illustrated at FIG. 5;

FIG. 7 is an essentially schematic elevational partial view of yet a further modified arrangement of the embodiment illustrated at FIG. 5; and

FIG. 8 is essentially a schematic elevational view illustrating yet a further modification of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 generally indicates, as at 10 a portion of a forming section of a twin wire web forming machine embodying the instant invention and comprising from left to right, a first sequence S1, a second sequence S2 and a portion of a third sequence designated as S3. In each of such sequences, S1, S2 and S3, a new ply of web is formed and is merged with the moist web ply or plurality of plies already on a main bottom forming wire 11. Such pre-formed moist web ply or plies carried on the bottom main wire 11 is designated as P₀ coming into the first sequence S1; P₁ coming into the second sequence S2, and P₂ coming into the third sequence S3.

It will be seen that the main bottom wire 11, which is a conventional woven metal fabric wire (although it might be a plastic wire or other wire for special purposes) is guided, as by breast roll 11a so as to pass over an initial large roll 12 (having a large curved surface) so that the wire 11 wraps on substantially its upper down-running quadrant Q12. In the first sequence S1, there is also a short looped upper auxiliary wire 13 having a plurality of guide and drive rolls 14, 15, 16 and 17 mounting the same and driving the looped auxiliary wire 13 at substantially the speed at which the bottom main wire 11 is traveling through the sequence S1. It will be seen that there is a reach 13a of the auxiliary wire 13 which extends from a first top guide roll 14 to a lower guide roll 15 (which may be considered a third guide in the sequence, since the large roll 12 guides the top wire reach 13a as well as the bottom wire 11). The rolls 14 and 15 maintain the top wire reach 13a under tension as it is wrapped into the configuration shown about the bottom wire 11 on the large roll 12. As is apparent, the deflected top wire reach 13a is free from restraining means in contact therewith opposite the bottom wire 11 throughout the quadrant Q12 of the large roll 12. Skimming deflector means, indicated at 13b and 11b at approximately the on-coming side of the guide roll 15 are shown only schematically, but such deflectors operate in close-running relation to the wires 11 and 13, and are actually closely spaced therefrom so as to skim water carried along the back side of such wires without exerting excessive pressure or bearing force on the traveling wires in the sense of a direction changing guiding type of contact (or pressure). These type of skimmers can also be positioned along the quadrant Q12 as desired. Appropriate save all

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devices (not shown) may be positioned beneath each such deflector and wipers 12a, 22a, etc. may be provided along the on-coming side of rolls 12, 22, etc.

The top guide roll 14 may thus be considered as a first guide in the succession of guides 14, 12, and 15 whereby the top wire 13 traveling over the first guide roll 14 and bottom wire 11 traveling over the second guide roll 12 at substantially the same speeds are brought into initially close spacing, as at J1 for receiving therebetween a jet-stream of web forming stock from a head box means, indicated essentially schematically at 18 and having a slice outlet at 18a. The slice outlet 18a feeds a stock jet stream into a spacing J1 between the wires 11 and 13. The wires 11 and 13 are brought through gradual convergence in a web forming zone (generally indicated by the dimension of F1) and into substantial parallelism with the ultimately formed fibrous web ply being substantially merged with the original preformed web P₀ carried into the forming zone F1 on the bottom wire 11. It will be appreciated that the wires 11 and 13 are in such substantial parallelism, that the tension on the wires will cause a continued squeezing of moisture in the stock (or moist web) therebetween. Additionally, the change of the direction of wire travel over the surface of roll 12 causes centrifugal force to be exerted on the moisture in the stock and to be thrown through the wires and away from a forming zone. The wires also pass the skimming deflectors 13b and 11b and then turn comparatively abruptly about the third guide, i.e. the suction roll 15, so as to wrap the suction area 15a of such suction roll in order to effect yet further dewatering. In this instance, the dewatering is carried out in part by water drawn in and held in a suction area and also by water thrown through and from the main wire 11 as it turns about roll 15. The wires 13 and 11 then continue in such substantial parallelism with the newly formed moist web P₁ therebetween until they reach the guide roll 16 for separating the top auxiliary wire 13 from the web and a suction roll 19 having a suction area 19a engaging the underside of the main bottom wire 11 for maintaining the newly formed web P₁ thereon as it passes to the next sequence S2.

It will be appreciated that the elements shown in the second sequence S2 which correspond to those already described in connection with the first sequence S1 are designated by the same reference numerals in the twenty series. Thus, the initial three successive guides are shown as the top roll 24, the large roll 22 and the lower suction roll 25. A fresh dilute aqueous suspension of entangled co-moving web fibers will exit from the slice 28a as a high speed substantially unidirectional ribbon-thin jet-stream into the spacing J2 that is effected initially by the guides 24 and 22 serving to bring the top wire 23 into initially close spacing with the bottom wire 11 at the large end J2 of the region of convergence which defines the forming zone F2 for the new ply that is being formed in sequence S2 and ultimately merged into the composite web product P₂ leaving the sequence S2.

As indicated in FIG. 1, the arrangement in each of the sequences S1, S2, S3, etc. are extremely simple and afford a considerable amount of versatility in operation. Also, such arrangements are found to give good wire life to the typical short wire loops 13, 23, etc. in that such short wire loops 13 are carried entirely by co-moving guide elements in the form of rolls 14, 16 and 17 and the suction roll 15, arranged to avoid excessive reverse bending. Likewise, the main bottom forming wire 11 is mounted only in co-moving elements which are indicated as the large rolls 12, 22, etc. and the smaller rolls 19, 29, etc. The bottom wire 11 will actually have a lower return run, and the view in FIG. 1 shows what constitutes the upper run of the wire 11, but it is functionally the bottom wire in the arrangement hereshown and it is so designated for convenient reference.

In spite of the apparent simplicity of the overall arrangement shown in FIG. 1, certain functional and very

significant operational advantages are afforded in this arrangement. It has been indicated that in all except an original web forming sequence in the overall system designated 10, there will be a pre-formed moist web ply traveling on the bottom wire 11. This being the case, the dewatering at the forming zone indicated in FIG. 1 at F1, F2, F3, etc. involved forming zones wherein dewatering will take place primarily through the top wire runs 13a, 23a, etc. although some dewatering will also take place through the lower main wire. This affords a substantial convenience in cost and maintenance by allowing the use of a plain large roll for the rolls 12, 22, 32, etc. Of course, perforated or imperforated (i.e. open) rolls (as more clearly described hereinafter) can also be used, especially where an initial web ply is first applied to the bottom wire 11, but this would not be absolutely necessary either and the very first sequence could operate substantially as has been described already in connection with the sequence S1, except there would be no initial ply P₀ carried on the bottom wire 11. The bottom wire 11, however, should wrap the roll 12 to obtain the desired centrifugal dewatering of the stock in the area of the forming zone F1.

Referring now to FIG. 2, certain of the more significant advantages of the individual sequences will be described; and the sequence in FIG. 2 will be designated for a convenient reference as S4 and all of the various elements of FIG. 2 which correspond to elements previously described will be designated by the same reference numeral in the 40 series. Thus, the inlet 48 shown only partially, has a slice from which a substantially unidirectional ribbon-thin jet-stream exit in a predetermined direction at a predetermined linear speed (signified merely by the arrows and dashed lines). Also, this sequence S4 is provided with spaced successive first 44, second 42 and third 45 guides (or guide rollers) and opposed top 43 and bottom 11 forming wires or belts traveling at substantially the jet stream speed over the first guide roll 44 and the second guide roll 42, respectively and through initially close spacing at J4 for receiving therebetween the jet-stream and substantially immediately thereafter through gradual convergence in a web forming zone F4 and into general parallelism with the fibrous forming web therebetween, in which parallelism the wire runs 11 and 43 travel downstream together over the third roll guide 45 in a manner already described in connection with the previously discussed sequence.

In the embodiment of FIG. 2, it will be seen that the skimming deflector 43b for the inside of the top wire 43 is shown in closely spaced close-running relation to the wire 43 and is also shown as part of a larger save-all assembly 43c. A skimming deflector 11b is likewise shown in a very closely spaced close-running relation to the wire 11 and is a part of a save-all assembly 42b, which includes a wiper 42a at the up-running side of the large roll 42.

There are several advantages which may be considered in connection with the specific form of the invention illustrated at FIG. 2. For example, although adjustability as to the extent of wrap by the top wire 43 and also as to the tension of the top wire reach 43a between the guide 44 and 45 may be adjusted by a number of different ways, such adjustability as indicated only schematically by the double-headed arrows designated 44a for the top roll 44 hereshown. It has already been pointed out that a substantial amount of wrap of both wires in the upper down-running quadrant Q42 for the large roll 42 is important. In the light of the available control of tension on the wire reach 43a, it will be appreciated that, at any given operating speeds and conditions at the stock jet slice 48a, the tension of the reach 43a affords a self-adjusting and steady pressure forming zone wherein control of these essential conditions is readily achieved.

Under such conditions as the self-adjusting of the pressure within the forming zone F4 which is here afforded,

it may be appreciated that the overall length or peripheral dimension available for use as the forming zone may extend from approximately the location designated A near the top of the roll 42 to the location designated B near the end of the quadrant Q42 (at which location the wires 11, 43 are actually separated from the surface of the roll 42 by the guide roll 45, which can also be adjustably positioned so as to change to some extent the point of separation of the wires from the surface of the roll 42). The present arrangement, the roll 42 has a preferred diameter of four feet and the actual forming zone F4 has a peripheral dimension α , preferably equal to about 75°. As a practical matter, however, the peripheral dimension of the forming zone may range from about 10° to as much as about 180° (and preferably ranges from about 60° to about 90°). Dewatering of the jet-stream at the relatively large diameter arcuate surface A-B of the roll 42 is effected by the centrifugal force resulting from the arcuate travel of the wires carrying the newly forming web therebetween around the portion A-B of the roll 42 and by the pressure caused by the wire tensions acting against the web expressing water therefrom.

Still an additional feature of significance in connection with this arrangement resides in the fact that there will be a hydraulic head "h," substantially equal to the overall vertical dimension from A to B, which affords development of higher drainage pressures within the forming zone F4, without a sacrifice of velocity head of the stock between the wires. In this respect, the size in alignment of the forming zone F4 will reflect the development of pressure resulting from this hydraulic head h independently of the machine speed which affords a distinct advantage in additional control of the operation. In other words, the head h will be constant irrespective of the speed of the machine and the extent of the centrifugal force.

Another at least partially independent aspect of control of the drainage pressure is afforded via the alignment in speed of the jet-stream feeding into the initial close spacing J4 between the wires 11 and 43. It will be appreciated that the traveling speeds of the wires 11 and 43 are controlled so as to be substantially equal; and such speed is likewise substantially equal to that of the stock jet-stream, but not necessarily absolutely identical thereto. In other words, as shown by the slight apparent expansion of the stock jet as at SJ4 just beyond the top of roll 42, the stock jets may be adjusted so that at this specific region SJ4, a certain amount of the jet-stream speed is lost and converted to pressure normal to the wires 11 and 43, i.e., an initial drainage pressure. In this way, the inlet to the forming zone is adequately sealed (i.e. in the general region of J4) and effective drainage and incipient web formation is thus initiated rapidly.

Also, the general curvature of the wires 11 and 43, and primarily of the bottom drainage wire 11, is a curvature that is generally consistent with the trajectory of the jet, at least to the extent that by selective adjusting of the alignment of the jet (by an adjustable means, indicated schematically at 48b by the two-headed arrow) it is possible to co-relate the jet trajectory much more closely with the general curvature of the wire in this arrangement, and in so doing, effect the type of sealing of the jet at the nip region SJ4 in the manner indicated schematically herein, which essentially involves the continuous maintenance of a slight expansion of the stock stream to slightly greater thickness than the jet-stream itself at this closely spaced nip of the converging wires. It will be appreciated that the maintenance of the slight stock expansion at the region SJ4 is a condition that can be stabilized during operation and the expansion thus maintained continuously so as to afford a pressure within the stock body during the initial web formation. Impingement of the stock into the area SJ4 avoids any significant disturbance of the jet stream, such as may be caused by the partial pressure experienced on the off-running side

of solid surfaces in phenomenon commonly known as pumping.

As indicated previously, in the case of the formation of an initial ply, an open roll (perforated or imperforated) free from the wrap of the forming wires and facing down in the position 42 would have its advantages because of the convenience of gravity assisting dewatering of the roll into which water had been forced during the forming period; but in the case subsequent formation applies, the economic advantages of a solid roll are available and the problem of drainage control is quite simple and easily handled. There is no need for deflectors or other devices causing a pressing of the wires together, since the wires 11 and 43 are pressed together while co-moving and while engaging a co-moving guide in the form of roll 45. The skimmers 43b and 11b simply serve to avoid any tendency to over-load a connection with the drainage at the immediate location of the roll 45 which will, of course, press the wires together against the newly formed moist web sandwiched therebetween and effect additional dewatering thereof.

In the embodiment described in FIG. 2, it will be appreciated that the hydraulic head h is approximately one foot or slightly more in dimension, but advantage resulting from the use of such hydraulic head in dimensional ranges from one inch to perhaps six feet are effected (the preferred dimensional range for the hydraulic head ranges from about one half to two feet).

Additionally, it will be appreciated that the arrangement of FIG. 1 permits formation of an initial ply at a first sequence S1 (where P_0 would have no meaning or would indicate that no ply was already on the oncoming wire 11); and subsequent sequences could then apply successive plies as disclosed. In so forming the initial ply the forming zone is readily adjustable with regard to its peripheral dimension. Below the first quadrant Q12 (i.e. for as much as the next 90° of the right-hand lower down-running quadrant) the second wire 13 will be used to control stock flow while web formation is still in progress to the extent that there may be free stock on the surface of the web undergoing formation. The hydraulic head would, in the last mentioned situation, extend from the point of initial deposition of the jet-stream J1 onto the roll 12 downwardly to substantially the lower end of the actual forming zone, so that the jet-stream may continue in this path without substantial velocity loss but with continuous internal pressure increase via the increase hydraulic head.

An important advantage of the invention resides in the use of a relatively large diameter roll 12 having a peripheral contour in the upper quadrant Q12 such that the configuration of the lower wire 11 supported thereby may closely approximate the natural configuration (i.e. trajectory) of the stock jet-stream J1 exiting from the inlet at the selected thickness and linear speed (and as it is effected by gravity, etc.). The more closely the traveling wire 11 may be co-related to this configuration (i.e. jet trajectory) and to the speed of the jet-stream, the less necessary the top wire 13 becomes (at least at the early stages of web formation); but conversely the advantages afforded by the top wire 13 varies from helping to contain the jet-stream, to affording still more fine and delicate control as to the jet-stream speed, as by excluding resistance of ambient atmosphere, and by the pressure which wire 13 can exert in complementing the hydraulic head effect. The optimum control under the foregoing conditions is obtained in the upper quadrant Q12, and by using this region as the main forming zone (so that its configuration as defined by both wires 11 and 13 most closely represent the jet trajectory), the additional advantage of separating both wires 11 and 13 from the periphery of the roll 12 at least substantially by the end of the upper quadrant Q12 permits gravity dewatering of the unwrapped roll 12 under the most favorable conditions. In conforming both wires to the trajectory inherent in the jet, the roll 12 is selected for

optimum size (i.e. diameter) and optimum position below the inlet 18a. The jet-stream velocity and thickness are likewise co-related to conform as closely as possible to those required for producing the trajectory best suited for the roll size and position, which will determine primarily the lower wire 11 configuration. The configuration of the upper wire 13 is determined by roll 12 and the wire 11 positions and configurations, plus the tension effect of rolls 14 and 15 on the wire 13 as urged against the jet-stream on the wire 11 which, of course, resists the wire 13 (deflecting it with the initial force of the stock stream).

Referring now to FIG. 3, certain of the most significant advantages of another embodiment of the individual sequences discussed in relation to FIG. 2 will be described; and the sequence in FIG. 3 will be designated for convenient reference as S5 and all of the various elements in FIG. 3 which correspond to elements previously described will be designated by the same reference numeral in the 50 series. Thus, the inlet 58, shown only partially, has a slice 58a from which exits a substantially unidirectional ribbon-thin jet-stream in a given direction and at a predetermined linear speed. Also, this sequence S5 is provided with space successive first 54, second 71, and 52, and third 55 guide members and opposed top 53 and bottom 11 forming wires traveling at substantially the jet-stream speed over the first guide 54 and second guide 71 and 52 respectively and through initially close spacing at J5 for receiving therebetween the jet-stream and thereafter through gradual convergence in a web forming zone F5 and into general parallelism with the fibrous forming web therebetween, in which parallelism the wire runs 11 and 53 travel downstream together over third guide 55 in the manner described in the previously discussed sequences. Of course, as will be appreciated, if desired, a single ply can be formed and removed from the sequence S5 by an appropriately positioned pick-up felt (not shown) downstream of the roll 55.

The sequence illustrated at FIG. 3 is especially useful where there is a tendency for the jet-stream of stock to be trapped between the converging wires 53 and 11 and be squeezed outwardly at the sides of the machine so as to "spew." To reduce this tendency, the arrangement illustrated in FIG. 3 is utilized to reduce the rate of convergence of the wires as gradually as possible. In other words, the effective diameter of the roll 52 is increased by the utilization of a stationary curved surface for plate 71 located between the roll 52 (at the on-coming side thereof) and the head box outlet 58a so as to extend into the nip or area of convergence formed between the wires 53 and 11 as they meet on the periphery of roll 52. The bottom wire 11 is trained over the arcuate stationary surface of the plate or shoe 71 as the jet-stream is deposited thereon from the head box nozzle 58a. In this manner, the rate of convergence between the two wires is more gradual and consequently dewatering pressure on the jet-stream is applied in a more uniformly increasing manner. It will thus be appreciated that the combination (or cooperation) of the plate or shoe 71 with a large diameter roll 52 provides a relatively large arcuate surface which more readily assumes the trajectory of the jet-stream and allows for a more uniform application of pressure to the jet-stream as it is deposited between the wires. Thus, in effect, the portions of the curved stationary surface 71 and the cylindrical roll 52 cooperates to provide a single wire guide having a relatively large diameter arcuate surface whereby the initial curvature of the nip between the converging wires is much less than would otherwise be available. Thus, the roll 52 is positioned immediately adjacent the off-running side of the shoe 71 and the actual spacing between elements 71 and 52 is not critical. Only the cooperation of these elements to define a gradually converging path of wire travel is essential so that other dewatering elements, not interfering with this cooperation, can be positioned therebetween. The curved plate 71 effectively increases

the diameter of the forming rolls in a relatively simple manner and, since the rate of curvature of this plate is relatively small, very little, if any, normal (i.e. perpendicular) loading of the wires occurs at such plate. The curvature is such that as the wires are nipped together, they experience every increasing curvature up to that of the roll and thereafter experience a relatively constant curvature substantially as shown to produce centrifugal forces on the newly deposited web between such wires for dewatering thereof. The curved plate 71 is machined or manufactured for having a desired radius of curvature, which may be constant (as shown at FIG. 4 at plate 171) or have a decreasing radius of curvature in the direction of wire travel (as shown at plate 71). Additionally, the surface of plate 71 may be perforated or imperforated.

The wires 11 and 53 gradually converge until they actually attain general parallelism, as by contacting the rotating peripheral surface of roll 52. The term general parallelism or substantial parallelism as utilized herein is defined for the purposes of the instant discussion as describing a dynamic concept of two wires spaced apart by a moist web continuously moving closer to each other as water is removed from such a web. The wires continue traveling in such substantial parallelism through the forming zone F5 and down to third guide 55. Guide 55 is here shown as a suction roll having a suction gland 55a, and in one embodiment, an adjustment means 55b is mounted thereon to allow adjustment of the amount of wire wrap on the roll 52. A similar adjustment means 54a is also provided on roll 54 to likewise control the amount of wrap of the wires over the guide surfaces. As the wires diverge from the surface of roll 52 they contact skimming devices 53b and 11b along the respective inner surfaces to remove water therefrom. These skimming devices 53b and 11b may be incorporated with conventional save-all devices 53c and 52b to prevent the removed water from re-contacting the forming web. Save-all device 52b may also be provided with a wiping device 42a for removing adherent water droplets and the like from the peripheral on-coming surface of roll 52 prior to its contact with the main forming wire 11.

FIG. 4 indicates generally, at 100, a portion of a forming system of a twin-wire web forming machine embodying the instant invention the sequence described in FIG. 3. It will be noted that generally the various elements are quite similar to that illustrated in FIG. 1, except that various elements are designated in the 100 series and that only successive sequences are shown. From left to right a first sequence S11, a second sequence S12 (only a portion of which is shown) are designated and it will be understood that additional sequences may be utilized as desired, and that these sequential sequences cooperate to produce a multi-ply web of a desired thickness. In each such sequence S11, S12, etc. a new ply of web is formed and merged with a moist web ply or a plurality of plies already on the main bottom wire 111. A pre-formed moist web ply or plies carried on the bottom main wire 111 designated P₀ coming into the first sequence S11; P₁₁ coming into the second sequence S12, etc. It will be seen that the main bottom wire 111 passes over a stationary curve (water-impermeable) shoe or plate 171 having a relatively constant radius of curvature and immediately thereafter over a relatively large diameter rotating roll 112, to wrap roll 112 on substantially its upper down-running quadrant Q112. In the first sequence S11, there is a short loop upper or auxiliary wire 113 having a plurality of guide and drive rolls 114, 115, 116 and 117 mounting the same and driving the looped wire 113 at substantially the speed at which the bottom wire 111 is traveling through the sequence S11. The reach 113a of the top wire 113 extends from the first upper guide roll 114 to a lower guide roll 115. The guide rolls 114 and 115 maintain the top wire reach 113a yieldably under tension as it is wrapped in the configuration shown about the bottom wire 111 on the large roll 112.

Also the deflected top wire reach 113a is free from restraining means opposing the bottom wire 11 throughout its travel of the quadrant Q12 of the large roll 112. However, it will be appreciated that dewatering elements, such as skimming deflectors and the like, could be positioned in close running contact with the wire 113 throughout its travel of the quadrant Q12 for removal of any expressed water. Various skimming devices and foil means, as indicated at 113b and 111b are positioned in close-running relation with opposed surfaces of the wires to skim water therefrom without exerting excessive pressure on such wires and may be integrally connected with conventional save-all devices 152b. Of course, wiping means, such as schematically indicated at 112a, can be connected with the various rolls for cleaning the on-coming surfaces of such rolls.

The gradual convergence of the bottom wire 111 with the upper wire 113 over the relatively large radius guide surface defined by the stationary shoe 171 and the roll 112 prevents spewing of the jet-stream from between the wires and serves to define a continuous bi-radii path of travel having a first radius of curvature substantially larger than the second radius of curvature. Apparently, spewing of stock from between the wires is limited or at least dependent upon the rate of pressure increase in the nip. Thus, when the pressure between the wires increases to a sufficiently high value, which may be only a few inches of water, the stock between the wires becomes thickened through drainage and such stock will be forced out between the wires in a spewing manner. Decreasing of the initial curvature of the nip between such wires allows the jet stream of stock to be subjected to generally uniformly increasing gradual pressure, materially aiding in the dewatering thereof and preventing spewing. The stationary arcuate plate or shoe, designated 171 in the sequence S11 and 171a in the sequence S12, increases the effective diameter of the roll 112 and 122 respectively and thereby allows a more gradual consolidation of the jet-stream between the two wires as they approach each other and the roll surface.

A method embodiment of the invention based on the foregoing system comprises introducing a stream of web stock between co-moving and converging opposed wires, guiding the superimposed wires with the stock sandwiched therebetween around a portion of a periphery of a wire guide having a large curved surface whereby the stock is dewatered through one or both wires as the combined action of centrifugal force and consolidation of the stock by the wire tension acts to dewater the stock. The newly forming web is carried onwardly for further dewatering over additional guides before the wires are separated to expose a web. The curved wire guide may comprise a large diameter roll or a combination of a stationary arcuate plate positioned on the on-coming side (preferably without the intervention of any elements which cause any meaningful change in the direction of wire travel) of a large diameter perforated or imperforated roll whereby the effective diameter of such a roll is materially increased.

The apparatus embodiment based on the systems of the invention described comprises first and second continuous forming wires, which are preferably foraminous, arranged to converge and provide an entrance nip for the reception of stock, a curved guiding element adjacent the entrance nip, means for supporting the wires within their respective loops and moving them into said entrance nip, with the wires being arranged to travel over the guide elements downstream of the entrance nip while having stocks therebetween around a part of the periphery of the guide elements so as to centrifugally dewater the stock between such wires. In one specific form, the guide element comprises a portion of the surface of a large diameter perforated or imperforated roll and in another specific form the guide element comprises such a roll preceded by a curved stationary perforated or imperforated surface positioned to define a continuous bi-radii path of travel with the roll.

The remainder of the discussion will now be devoted to the embodiments of the invention forming a single web ply, however, it will be understood that this is not a limitation but merely further exemplary embodiments of the invention.

FIG. 5 illustrates a forming section 210 of a web forming system. The head box means 211 is connected to a slice chamber 211a, having a plurality of simultaneously converging sidewalls 211b, 211b' and a slice outlet 211e. The head box provides a supply of web stock to the slice chamber 211a. The slice outlet 211e is positioned at the upstream end of the system 210 so as to provide a jet-stream of stock in a given direction. Upper sidewall 211b' is provided with an adjustable lip 211c for selectively adjusting the size of the slice opening 211e. A power adjustment means PA is positioned above movable lip 211c for selective adjustment as indicated. A plurality of flexible trailing elements 212 are suitably mounted within a slice chamber 211a. It will be noted that the trailing members 212 are arranged to define plurality of converging channels 213 therebetween directing the passage of web stock therethrough toward the opening 211e. Thus, an essentially symmetrical slice chamber 211a is attained. The slice chamber 211a is exceptionally well suited for producing a dilute aqueous suspension of entangled co-moving fibers having a relatively low degree of turbulence and a relatively high degree of dispersion exiting downstream-wise from the slice opening 211e as a high-speed substantially unidirectional ribbon-thin jet-stream. Additional details of such a preferred slice chamber are disclosed and claimed in copending Hill et al. application, U.S. Ser. No. 698,633, now Pat. No. 3,607,625, which disclosure is incorporated herein by reference. It will be appreciated that other slice chambers produced in the desired characteristics within the jet-stream may also be utilized.

A pair of breast rolls 215 and 216 (open or solid) are mounted along a common plane in working relation with the slice chamber 211a. The breast rolls 215 and 216 are spaced apart a distance somewhat greater than the transverse or ribbon-thinness dimension of the jet-stream so as to define a nip or gap G therebetween. In this regard, it will be appreciated that rolls 215 and 216 need not have their axes exactly aligned along either a horizontal or vertical plane and that one or the other of such rolls may be aligned so as to have its axes along the generally parallel but different vertical or horizontal planes. The spacing between the surfaces of such rolls actually defines the gap G and not the roll axial alignment. The jet-stream exits from the opening 211e of the slice chamber 211a into the gap G in a pressure-creating relationship. The relationship is such that substantially no flooding occurs at the gap G and the speed of the jet-stream is substantially converted into pressure. It will be noted that in the arrangements shown, the jet-stream is orientated upwardly. A first forming wire F_1 wraps the first breast roll 215 and travels therewith through the gap G, while the second forming wire F_2 wraps the second breast roll 216 and likewise travels through the gap G. The forming wires are respectively trained over a plurality of wire guides 218, 219, 221 and then respectively over guides 223, 215a, 224 and 216a to define a first and second wire run. For sake of convenience, the first wire and first wire run will be referred to by reference designation F_1 while the second wire and second wire run will be referred to by the reference designation F_2 . These forming wires may be composed of bronze, steel, copper, plastic or even fabric strands woven in an open mesh to define endless loops. The forming wires may also be formed of a plurality of different materials combined to yield certain specific characteristics, i.e. wear, stretch, weight, strength, dewatering characteristics, etc.

While it is previously indicated that the jet-stream of stock impinges into the gap G between the rolls 215 and 216, it will be noted that in fact, the jet stream impinges

on the surfaces of the forming wires F_1 and F_2 as they travel over the rolls 215 and 216 and that the stream contacts one of the wires, i.e. F_1 before the other. Dewatering occurs at the off-running side of the roll 215 and 216 by essentially a drainage phenomena without any "pumping" by the rolls. Pumping is generally defined as the action of a diverging solid surface acting on a moving stream (of stock or newly forming web) by creation of at least partial vacuum at the off-running side of such surface which tends to pump or pull water from the stream and thereby disrupt it. During early stages of web formation, pumping is detrimental to proper distribution and thus is to be avoided. At this early stage of the forming section, substantially little, if any mechanical pressure is exerted on the stock. This "easy" pressure allows a substantial portion of the water to be drained from the forming zone without the application of disruptive pressures, which may cause shearing or like effect disturbing the proper formation of a web. The dewatering, as indicated at a first area A_1 and at a second area A_2 , is in substantially opposing directions so that simultaneous drainage, without pumping, takes place along both surfaces of the newly forming web allowing proper distribution of the fibers within the web. The forming wires F_1 and F_2 continue to travel convergently together into general parallelism over dewatering guides positioned downstream of the gap G.

The term "general parallelism" as used herein is to be understood to include the dynamic or changing relation of the wires toward one another as caused by the slight spacing or separation of such wires by the sandwiched web or web stock therebetween and allow the slight movement of the respective wires toward one another as water is removed from such sandwiched web. As will be appreciated, as the stock (sometimes referred to as the jet-stream) is dewatered, the wire tension urges the wires closer toward one another due this smaller quantity of matter between such wires. Thus, the tensioning of the respective wire runs materially aids in properly dewatering the forming web.

The first curved guide surface encountered by the converging wires is wire guide 218 which comprises an essentially elongated, smooth, stationary generally convexly curved surface urging the wire F_2 into general parallelism with wire F_1 . It is to be noted that wire F_1 is free from restraining means throughout its travel through the forming zones, i.e. it is not associated with any elements which would prevent water from being expressed through its inner surface. In the embodiment here illustrated, wire guide 218 is shown as being water-impermeable, however, as will be discussed in relation to FIG. 7, it may also be water-permeable. The generally elongated curvature of the wire guide 218 allows the application of "easy" pressure (a gradual build-up of pressure between the forming wires) and avoids spreading or spewing large volumes of water from between the wires causing flow disturbances due to relatively abrupt and/or intensified pressure changes between such wires. In addition, the general curvature of the wire guide 218 causes little if any normal loading of the traveling wires against the wire guide 218. The greatest loading actually occurs at the off-running side of the wire guide 218. Substantially little, if any wear takes place along the surface of the wire guide 218 since a minimal amount of frictional contact between the moving wires and the stationary surface takes place. It will be noted that the forming wires F_1 and F_2 do not come into actual parallelism with one another until some point 218a well beyond the lead edge of wire guide 218. During the gradual convergence of the wires into general parallelism additional pressure is exerted upon the newly forming web to express additional water therefrom. The water is thrown through and away from the exposed side of the forming wire F_1 which is, of course, free from contact with any restraining means as defined hereinbefore. The expressed water is collected in a save-all

device 217 having a conduit C directing the expressed white water back to the head box or other desired location. A conventional doctor means 216b is trained on the off-running side of the roll 216 to remove any adherent water particles, etc. from the surface of roll 216 and direct the same into the save-all device 217. Of course, similar doctor means can be associated with the various other rolls shown.

A large diameter foraminous roll 219 is positioned downstream of the third wire guide 218, and preferably immediately downstream of the off-running side of the wire guide 218 so as to define therewith a continuous bi-radii path of travel having a first radius of curvature substantially larger than the second radius of curvature. As indicated in conjunction with the discussion relating to the earlier embodiments, the stationary surface 218 and the roll 219 are so positioned in respect to one another as to define a continuous bi-radii path of travel, however other dewatering elements positioned between the curved stationary surface and the roll which do not alter the continuous bi-radii path of travel are within the scope of the invention. The roll 219 is here shown as being an open breast roll having a perforated surface 219a for receiving water expressed through the bottom wire F₂. As will be appreciated, dewatering takes place on both sides of the sandwich arrangement, i.e. water tends to be thrown away from the wire F₁ by virtue of centrifugal forces and into the openings of roll 219 by virtue of positive pressure between the wires.

The relatively large radius of curvature of wire guide 218 substantially prevents normal or perpendicular loading of the wires F₁ and F₂ against the surface of the wire guide 218. In this manner, relatively little wear takes place between the traveling wires and the stationary wire guide surface 218. The greatest amount a wire loading occurs when the wires come in contact with the rotary surface of the roll 219. However, since the surface of the roll 219 is rotating, substantially little frictional force is developed between the surface of the roll and the traveling wire so that no detrimental effects are encountered by the virtue of the increase loading on the wires. In the arrangement shown, the roll 219 guides the traveling wires through a substantial curve, of for example about 90°, in a direction away from the jet-stream direction at the slice opening 211e or the gap G. The rate of turn through which the traveling wires are forced by the curved guide elements is sufficient to cause dewatering to occur by driving water through and away from the exposed side of forming wire F₁. As will be noted, the exposed or inner peripheral side of the forming wire F₁ is free from any restraining means (as defined hereinbefore) throughout the entire forming zone. The roll 219 is driven by virtue of tension in the traveling wire runs, which are driven at substantially the jet-stream speeds so that there is substantially no relative movement between the traveling wire runs and the supporting surface of wire guide 219. Further, at this stage of the forming zone, the newly forming web will still be in a relatively fluid stage and the relative shifting between the wires as they travel over the rather abrupt curvature of roll 219 does not cause shearing or the like to take place within the newly forming web. In other words, some relative movement between two wires can be tolerated at this relatively early stage of the forming zone.

A laterally continuous dewatering means 219b is trained on the exposed inner side of forming wire F₁ at the off-running side of the roll 219. Dewatering means 219b is placed in extremely close working relationship with the traveling wire run to skim off water that may be adhering to the backside of the forming wire run. The dewatering means 219b thus engages and removes water that is adhering to the backside of the wire run but does not cause any wire-directional change and there is little, if any, frictional engagement between the traveling wires and the dewatering means 219b. Thus, it will be appreciated that stationary dewatering means 219b would

not constitute a restraining means for water being expressed through the backside of a wire. As shown, the dewatering means 219b removes the water from the wire F₁ and throws it into a save-all device 217 having an appropriate conduit C passing the expressed water to a desired location. As indicated hereinbefore, the abrupt change of direction that the traveling wires are forced to undergo by virtue of a curvature of the surface of roll 219 causes the water within the newly forming web to be thrown through and away from the exposed side of the forming wires. The wire tension continuously urges the wires toward one another so as to drive water from the sandwiched web, while the abruptly curved surface provides momentum to the expressed water along the surfaces of the wires away from the web. In other words, centrifugal forces and gravity are combined to effect a substantial amount of dewatering at the area of curvature of the various guides.

The two wire runs continue in general parallelism over an additional wire guide 221. The wire guide 221 presents a water-removing surface, here shown as a plurality of stationary suction boxes acting against one surface of the sandwich arrangement (wire-web-wire). It will be noted that during the initial travel of the sandwich arrangement over the water-removing surface of the wire guide 221, the inner peripheral surface of forming wire F₁ is free from contact with any detrimental restraining means while the inner peripheral surface of forming wire F₂ is in contact with the suction boxes of the wire guide 221 for removal of water therethrough. During the latter portion of travel of the sandwich arrangement over the suction boxes, the reverse occurs, i.e. suction box 221a contacts the inner peripheral surface of forming wire F₁ while the inner peripheral surface of wire F₂ is free from contact with restraining means. The newly formed web tends to adhere along the surface of wire F₁ and continues to travel therewith while diverging from forming wire F₂. A couch roll 223 and a turning roll 224 are positioned downstream of the wire guide 221. Forming wire F₂ is guided around turning roll 224 and along the plurality of guide roll 216a back to the upstream portion of the forming system 210. The guide roll 216a may be provided with tensioning means T₂, substantially as indicated, to maintain a desired degree of tension within the wire run. The first forming wire F₁ carries the newly formed web W along its outer surface and wraps couch roll 223, which is provided with a suction gland 223a to assist in maintaining the web on the wire F₁. The couch roll 223 directs the forming wire F₁ and the web W away from the forming section and toward a pick-up station. In the arrangement here shown, the pick-up station is defined by a roll 225 which is wrapped by a pick-up felt PF. Roll 225 is provided with a suction gland 225a which is maintained under subatmospheric pressure. The pick-up felt PF contacts the newly formed web at it travels past the roll 225 and the web W adheres to the pick-up felt and travel therewith toward a further station for processing as desired. The pick-up felt PF is, of course, trained around a plurality of guide rolls (not shown) defining its looped path of travel in a conventional manner. The forming wire F₁ continues to travel upwardly past the plurality of guide rolls 215a directing the wire F₁ back to the upstream portion of forming system 210. Guide rolls 215a may be provided with tensioning means T₁ substantially as indicated to maintain the desired degree of tension within the wire run.

The guide rolls 215a and 216a are also provided with a doctor blade 215b and 216b respectively, on their off-running side to cleanse the peripheral surfaces thereof. The doctor blades 215b, 216b direct any removed foreign materials, water droplets, etc. into a save-all device 217. Suitable drive means M₁ and M₂ are connected to certain of the rolls within the wire runs F₁ and F₂. In the embodiment here shown, rolls 223 and 224 are respectively connected to drive means M₁ and M₂, however, other rolls may also be connected to such drive means as de-

sired. The drive means urge the respective wire runs at speeds substantially equal to the jet-stream speeds, however, they may be regulated to drive the wire at other speeds for certain special effects.

Referring now to FIG. 6 wherein a further modification of this embodiment of the invention is illustrated. A forming system or section 320 is comprised of a head box means 311 having a slice chamber 311a orientated to have its outlet 311e directed in an upward direction. The slice chamber 311a is likewise provided with a plurality of flexible trailing members 311b arranged to define a plurality of converging channels 313 extending from the head box toward the outlet opening 311e. The converging trailing members 311b have a degree of flexibility allowing them to assume hydrodynamic stability within the stock flow. By positioning the entire head box means 311 upwardly, the bottom apron member 311a of the head box means need not be curved and the opening 311e can be positioned much closer to the forming gap G.

The arrangement of the various elements in the forming section 320 is quite similar to that described in conjunction with FIG. 6 and they are designated by the same reference numeral in the 300 series. Thus, a pair of breast rolls 315 and 316 are mounted for rotation along a generally common plane spaced apart a distance to define a somewhat vertically-extending gap G therebetween. The gap G is in close working relation with the slice opening 311e to receive the jet-stream of web stock therefrom. The rolls 315 and 316 are wrapped by forming wires F_1 and F_2 respectively and guide such forming wires through an initially close spacing at the gap G. The forming wire F_1 is a substantially continuous looped traveling wire having a path of travel defined by a plurality of wire guides 315, 318, 319, 321, 323 and finally 315a so as to constitute a first wire run, for convenience also designated F_1 . The second forming wire F_2 is similarly a looped traveling forming wire having a path of travel defined by a plurality of wire guides 316, 318, 319, 321, 324 and 316a so as to constitute a second wire run, for convenience designated F_2 . Wire guides 315a and 316a are provided with tensioning means T_1 and T_2 for maintaining a desired degree of tension within their respective wire runs. The paper stock discharges as a low-turbulence, high-dispersion and jet-stream toward the forming gap G so as to come into contact with the porous surfaces of the forming wire F_1 and F_2 .

In a preferred embodiment, the jet-stream does not contact the wires until the wires are well beyond the area of pumping influence rolls 315 and 316. Of course, in arrangements where rolls 315 and 316 are open rolls pumping is avoided without use of such expediency. In general, the speed of the jet-stream is sufficient to cause the water to be driven through the exposed surfaces of the forming wires at the off-running side of the breast rolls 315 and 316 by a drainage phenomenon, without disruptive pumping taking place. In this manner, a first dewatering area A_1 occurs through forming wire F_1 and a second dewatering area A_2 occurs through the forming wire F_2 so that substantially equal drainage takes place along opposed sides of the newly forming web. The traveling wires continue to converge together into general parallelism as they travel toward wire guide 318 and wrap a portion of its surface. The wires actually tend to assume general parallelism at a point 318a along the surface of guide element 318 so that a gradual build-up of pressure occurs throughout the area of convergence. As the wires continue converging together, the exposed side of forming wire F_1 is free from contact with any detrimental restraining means, thereby defining a third dewatering area A_3 wherein water is driven through and away from the exposed side of the forming wire F_1 . Skimming means and the like can be positioned along this portion of the forming wire run F_1 (along with appropriate save-all devices) to insure that overloading of this dewatering area does not occur.

The wire guide element 318 is substantially a stationary, smooth, generally convexly curved surface having a relatively large radius of curvature. The large radius of curvature prevents any substantially loading of the wires against the surface of guide element 318 so that relatively little frictional engagement takes place between the stationary surface and the traveling wire runs. A large diameter dewatering roll 319 is positioned in close-running relationship with the off-running side of the guide element 318 so as to provide an essentially continuous path of travel for the sandwich arrangement of the traveling wires and the newly forming web. The dewatering roll 319 is here shown as having an open or foraminous structure 319a, wherein the inner peripheral surface of roll 319 is provided with a plurality of pins or support structures carrying an outer water-permeable wire mesh or the like of conventional construction. Of course other dewatering rolls, such as suction rolls, grooved rolls, drilled rolls, etc. can also be utilized. The rotating surface of roll 319 offers essentially no frictional drag on the traveling wires and directs the sandwich arrangement through a rather abrupt curve in relation to the jet-stream direction at the forming gap G. The abrupt change of direction causes additional water to be removed from the sandwich arrangement at a further dewatering area A_4 . Of course, water is also driven in an opposing direction into openings 319a of roll 319. A save-all device 317 is positioned in the vicinity of the various dewatering areas to receive the express water for collecting the same and delivering it via a conduit C back to the head box for dilution of stock or to another location as desired. A laterally continuous dewatering means 319b and a doctor means 316b are operatively associated with save-all device 317 for directing any matter coming in contact therewith into such save-all device. The dewatering means 319b may be of any structure desired, however, preferably it is an air foil means such as shown and claimed in U.S. Pat. No. 3,377,236 generally comprising a stationary dewatering element having a rounded lead edge which engages water carried along the exposed surface of the forming wire F_1 without causing any wire-directional-changing engagement with the traveling wires. The sandwich arrangement continues traveling in a downward direction past a stationary dewatering guide 321, 321a substantially as earlier described. The wires F_1 and F_2 then diverge from one another with the newly formed web W adhering to the wire F_1 for travel therewith around a couch roll 323 having suction gland 323a. Wire F_2 travels around turning roll 324 and back to the forming gap G. The forming wire F_1 and the newly formed web W travel away from the forming section 320 and toward a pick-up station or the like substantially as explained in conjunction with FIG. 1. In certain embodiments of the invention. It may be preferable to position the turning roll 324 substantially below and to the right of couch roll 323 so that both wires wrap the couch roll during this area of direction change to insure that the newly formed web does not disintegrate or otherwise become disrupted as it is being guided away from the forming section. This type of couch-turning roll arrangement is further illustrated at FIG. 8.

Referring now to FIG. 7 wherein a somewhat modified web forming section 430 is partially illustrated. Various elements shown in forming section 430 corresponding to elements discussed in conjunction with FIGS. 5 and/or 6 carry the same reference numeral in the 400 series. Thus, a head box means 411 is positioned in working relation to a forming gap G. A pair of breast rolls 415 and 416 are mounted to rotation in a substantially vertical plane, each within the loop of one of the forming wires F_1 and F_2 substantially as set forth. It will be noted that the head box means outlet 411e is orientated generally upwardly to feed the jet-stream of co-moving fibers into contact first with the upper wire, i.e. F_1 and then with the other wire. This orientation allows sub-

stantial amounts of water to be driven through such upper wires. After the dewatering areas A_1 , A_2 the wires continue traveling convergently together into general parallelism over a curved wire guide 428 to attain such parallelism (which has heretofore been defined as a dynamic relation undergoing slight geometric changes as water is removed from the newly forming web) at a point 428a along the surface of the guide element 428. Respective forming wires F_1 and F_2 are trained over a plurality of wire guides as indicated herebefore to define first and second wire runs which are driven by substantially jet-stream speeds and maintained under tension as desired. As the wires converge together with the stock therebetween, a first dewatering area A_1 occurs at the off-running side of breast roll 415 and a second dewatering area A_2 occurs at the off-running side of the breast roll 416. As the wires travel in general parallelism substantially greater pressure is gradually applied on the jet-stream and additional dewatering takes place along a third dewatering area A_3 through the exposed side of the forming wire F_1 which is free from contact with any detrimental restraining means. The initial dewatering area A_1 and A_2 apply easy pressure on the stock between the wires which is defined for purposes of the invention as a compromise between abrupt pressure necessary to expel water from a web and slowly increasing or intensified pressure that avoids spreading or spewing of the paper stock beyond the wires.

The guide element 428 presents a substantially water-permeable surface to the second wire run F_2 and is defined by a plurality of longitudinally spaced generally transverse wire-contacting relatively thin edges 428b. The longitudinal contour of the wire-contacting edges 428b define the elongated convex curve of the wire guide 428. The relatively large radius of curvature of the guiding surface of guide element 428 prevents substantial normal or perpendicular pressure loading of the wires against the edges 428b thereby preventing undue frictional engagement between the traveling wires and the guide surface of the element 428. In certain embodiments, the guide element 428 includes a housing 428c along with an associated pump means 428d operationally connected therewith for maintaining of subatmospheric pressure at the water-permeable surface so as to aid water removal through the longitudinal spacing between the wire-contacting edges 428b. The conduit C is provided within the housing 428c for directing collected water away to another location. Thus, the water-permeable surface of element 428 defines a fifth dewatering area A_5 substantially opposed to the third dewatering area A_3 . While guide element 428 preferably has a convexly curved surface, it will nevertheless be appreciated that an essentially flat surface (having an essentially infinite radius) may also be utilized. The arrangement shown at FIG. 7 is especially useful for continuously dewatering a newly forming web along substantially opposed sides thereof thereby providing proper distribution of fibers within the web.

The sandwich arrangement continues traveling in the jet-stream direction so as to contact the portion of the surface of a relatively large diameter foraminous roll 419. Roll 419 is here shown as having an open surface 419a, however, other dewatering surfaces are also useful. The roll 419 presents a rotating surface to the traveling sandwich arrangement guiding the same through a substantial curve away from the jet-stream direction at a rate of turn sufficient to centrifugally dewater the sandwiched web and define a fourth dewatering area A_4 driving water through and away from the exposed side of the first forming wire F_1 . Of course, some water is also dewatered by the surface 419a of the roll 419. The roll 419 and guide element 428 cooperate to guide the wires through a continuous bi-radii path of travel substantially as described earlier. The forming wires then

continue traveling to an appropriate pick-up station, for example as discussed in conjunction with FIG. 6.

Referring now to FIG. 8, a forming section 510 is generally illustrated showing an arrangement somewhat similar to that discussed at FIG. 3 and including additional modifications, such as discusses at FIG. 6. A preferred head box means 511 is provided with an essentially symmetrical slice chamber 511a which includes trailing flexible members 512 defining a plurality of converging channels 513 therebetween allowing passage of stock toward an outlet 511e. A power adjustment means HP is operatively connected with the head box means 511 for orienting the slice chamber and outlet as desired. Continuously looped forming wires F_1 and F_2 are arranged to converge with one another at a gap G. Breast rolls 515 and 516 are each mounted within the loop of one of the wires in the manner described. The rolls 515 and 516 are provided with plural direction adjustment means Ra, as schematically indicated by the four-headed arrows, allowing selective adjustment of the gap dimension as desired. In the arrangement shown, roll 515 is shown as being an open breast roll, while roll 516 is shown as being a solid breast roll, however, both rolls could be solid or open as desired. The upward orientation of the slice outlet 511e and the gap G provides a more compact forming system wherein gravity assists in forming desired webs. Further, any excess stock or the like will fall down and away from the forming section and not interfere with the proper web formation. The wires are respectively trained over a plurality of guide elements 517 and 519 and then respectively over guides 515a and 516a so as to define first and second wire runs similar to those described earlier. The stock is impinged onto the surface of the forming wires F_1 and F_2 so that water is removed therefrom by an essentially drainage phenomena without any pumping or the like by the rolls that may cause streaking of the newly forming web. The dewatering, as indicated at a first area A_1 and a second area A_2 , is in substantially opposing direction so that simultaneous drainage, without pumping takes place along both surfaces of the newly web for proper fiber distribution within the web, yielding optimum strength, printing and the like characteristics. The forming wires continue to travel together convergently into general parallelism over the guide element 517. The guide element 517 is essentially an elongated smooth stationary generally convexly curved surface urging wire F_2 into general parallelism with wire F_1 while having stock sandwiched therebetween. The guide element 517 is here shown as being essentially water-impermeable, however, it will be appreciated that some slight amount of water as a film, will form on its working surface to act as a lubricant for the traveling wire run. Further, as discussed in conjunction with FIG. 7, a water-permeable surface can also be utilized. The generally elongated curvature of the guide element 517 is beneficial in allowing a gradual build-up of pressure between the forming wires and avoids spewing of large volumes of water from between the wires causing flow disturbances due to relatively abrupt and/or intensified changes between such wires. As already discussed, the curvature of guide element 517 avoids wear of the wire or of the guide element and is less expensive than providing a rotating surface having a similar radius of curvature.

The wires F_1 and F_2 do not come into actual parallelism with one another until a point 517a well beyond the lead edge of the guide element 517. The point of convergence 517a is actually adjustable by selective positioning of the breast rolls 515 and 516 via their respective adjustment means Ra as explained hereinbefore. This adjustment is necessary to allow the formation of various grades of webs, i.e. when tissue paper webs are being produced, the point of convergence will be substantially closer to the lead edge of the guide element 517 than when, for example, newspaper grade paper webs are being produced. During this area of gradual convergence of the wires into gen-

eral parallelism with one another, additional pressure is gradually applied upon the newly forming web so that water is thrown through and away from the exposed side of the forming wire F_1 in the manner shown, to define a third dewatering area A_3 . The expressed water (such as at areas A_2 , A_3 , etc.) is collected in an appropriate save-all device Sa , having a conduit C directing the expressed water back to a desired location. Similar devices are provided beneath the various areas where water is removed from the sandwiched forming web.

The utilization of an open breast roll and a stationary curved guide element in the initial stage of the forming zone provides a positive means of water movement control in this critical area of web formation and additionally provides increased drainage capacity with attending low drainage pressure which are very important for proper web formation. A flexible control is provided by the ability to adjust the clearance between the two traveling wire runs at the open roll location (i.e. at the forming gap G), control of the drainage capacities is presented by virtue of the increased length over which the traveling wires converge into general parallelism, while the low drainage pressure is primarily controlled via the relatively large radius of curvature of the guide element **517**.

The large diameter suction roll **519** is positioned downstream of the guide element **517**, preferably in close running relationship so as to define a continuous bi-radii path of travel having a first radius of curvature substantially larger than the second radius of curvature. As will be appreciated, the guide element **517** defines such first radius of curvature while the guide element **519** defines such second radius of curvature. The suction roll **519** is shown as a large diameter suction roll having a plurality of vacuum or subatmospheric chambers **519a**, **519b** and **519c**, each operatively associated with a means **519x**, such as pump means P schematically illustrated, for providing a select amount of subatmospheric pressure to each of the chambers. The vacuum pressure in each of the chambers **519a**, **519b** and **519c** are of varying strength and are preferably progressively of greater strength, i.e. of increased vacuum, than the preceding chamber in the direction of wire travel. Thus, for example, chamber **519a** is weaker than chamber **519b** which in turn is weaker than **519c**. As shown, the suction roll **519** receives the traveling sandwich arrangement of wire-web-wire and directs it through a curve away from the direction of the jet-stream at the slice opening **511e**. Since the surface of roll **519** is rotating, substantially little frictional force is developed between the surface of the roll and the traveling wires so that no detrimental effects are encountered by virtue of the increased loading on the wires. The rate of turn through which the traveling wires are forced by surface of the roll **519** is sufficient to cause dewatering to occur by centrifugal forces driving water through and away from the exposed side of the forming wire F_1 . Of course, water is also driven and retained within the individual chambers of the suction roll **519** so as to define additional dewatering areas A_x , A_y and A_z .

The roll **519** is driven (as by drive means M_2) at substantially the jet-stream speed of the stock and of the traveling wires so that there is little relative movement between the traveling wire runs and the supporting surface of the roll **519**. At the initial wrap of the traveling wires over roll **519**, the chamber **519a** provides a controlled amount of vacuum against the inner peripheral surface of forming wire F_2 drawing substantial amounts of water into the dewatering area A_x . This area is of relative small size, i.e., having an arc length of about 20° , since in this initial area of wrap the traveling wires are first guided away from the jet-stream direction and a substantial amount of centrifugal force will be produced on the traveling sandwich arrangement so that substantial amounts of water will be thrown away from this traveling structure and excessive vacuum at this area could be detrimental. The next subatmospheric compartments **519b** is substantially larger in size and has a higher degree of vacuum

thereby drawing additional amounts of water into the dewatering area A_y as shown. The arc length of compartment **519b** may be about 60° , which corresponds to a length of about 63 inches and would be comparable to about five or so suction boxes having a 12 inch length (conventional suction boxes). During this portion of the forming zone dewatering continues to take place upwardly through the forming wire F_1 with the aid of centrifugal forces and wire tension and downwardly by virtue of gravity and subatmospheric pressure. The final compartment **519c** generally compares to the vacuum length and drainage capacity available over a conventional suction couch roll and draws additional amounts of water into the dewatering area A_z as indicated.

As will be appreciated, greater amounts of vacuum can be applied in suction rolls than in conventional vacuum flat boxes due to less wire wear, less chance of seizure, etc. Thus, it will be noted that the instant forming arrangement completely does away with the necessity of utilizing stationary suction boxes, such as shown in the arrangements of FIGS. 5-7 and thereby decreases the dimensions of the forming section while substantially increasing the water handling capacity thereof. Additionally, it will be appreciated that the area of wire wrap around suction **519** may be adjusted so as to obtain more wire wrap thereby obtaining additional dewatering as desired. Of course, less wrap may also be utilized for forming light weight webs.

The further advantage of this arrangement is that roll **519** here functions as a couch roll so that the newly formed web W adheres to the lower wire F_2 and departs from the upper wire F_1 . The upper wire F_1 is guided by a turning roll **515a** and directed back towards a forming gap G while the forming wire F_2 continues to travel along an essentially straight line to a pick-up station generally indicated at PN having elements substantially similar to those previously described. Laterally continuous dewatering means **520** and **520a** are each respectively trained on the exposed inner peripheral surface of the forming wires F_1 and F_2 so as to skim off any water that may be adherent to the backside of the forming wire runs. The dewatering means engage and remove the water on the backside of the wire runs without causing any wire-directional change and there is little, if any, frictional engagement between the traveling wires and the dewatering means **520** and **520a**.

The forming system **510** allows the combination of centrifugal forces, gravity and vacuum to effect substantial amounts of dewatering in a relatively short space so that a very compact forming section is provided. As indicated hereinbefore, the roll **519** is driven by a suitable drive means M_2 and thereby reducing the load or tension on the forming wire F_2 and insure a longer useful life for the wire and less disturbances on the sandwich web. The drive requirements of the other forming wire, F_1 are also very low since there is no surface causing a heavy drag on this wire. Of course, wire F_1 is shown as being driven by second suitable drive means M_1 , which is synchronized with drive means M_2 so that both wires travel at substantially the jet-stream speed over the various guides and there is little relative movement between the two wires thereby avoiding scuffing or the like of the web that is sandwiched between such wires.

It will be noted that suction roll **519** functions as a couch roll in that it positions the newly formed web W for removal from the forming section **510**. As the traveling wires F_1 and F_2 pass over the last subatmospheric compartments **519c** of the roll **519**, they quickly diverge from one another and the newly formed web W adheres to the wire in contact with the couch roll, i.e. F_2 . In forming arrangements where a change of travel direction occurs at a couch roll, it is important to insure that the newly formed web does not depart from the couch roll but remains in contact with the wire contacting said couch roll for guidance to a pick-up station. In the arrangement shown, both wires wrap the couch roll **519** for a substantial portion of its peripheral surface thereby preventing the

newly formed web from deviating from the desired path of travel. Wire turning roll 515a controls the amount of wire wrap by wire F₁ over the couch roll 519. In certain arrangements, wire turning roll 515a is provided with a plural direction adjustment means, schematically indicated at Ra, allowing selective positioning of the roll 515a in respect to roll 519. It is important to position the roll 515a at a location insuring that the upper wire F₁ at least wraps that portion of the couch roll 519 wherein the greatest amount of direction change occurs.

An additional advantage of the arrangement shown is that if the web W should, for some reason break after passing beyond the protective sandwich arrangement, it will naturally fall downwardly into a broke-pit or the like and not otherwise interfere with the remaining web being produced.

The forming wire F₂ carries the newly formed web W along its outer surface along an essentially straight line of travel to a pick-up station PN. An exemplary pick-up station is here illustrated as comprised of a pick-up felt PF which is trained over a plurality of rolls, of which only roll 522a is shown, to define a conventional endless loop. A web transfer roll 522 is positioned within the loop of the pick-up felt PF and in close running contact with the wire F₂ so as to contact the web W carried by the wire F₂. The transfer roll 522 is provided with a suction gland 522b, which is maintained under subatmospheric pressure in a conventional manner and functions as an aid in transferring the newly formed web W from the forming wire to the pick-up felt. The pick-up felt carries a newly formed web for further processing as desired, i.e. to a first press section or the like.

As described earlier, the wire guide rolls 515a and 516a are positioned within the respective loops of the wires of F₁ and F₂ to guide the same in the continuous loop throughout the forming section 510. These wire guide rolls can be provided with conventional doctor means 515b and 516b respectively as well as tension means T₁ and T₂ as desired. Suitable drive means M₁ and M₂ are connected to certain of the rolls within the wire runs F₁ and F₂ to maintain the speed of the traveling wire runs at a selected speed, preferably at substantially the jet-stream speed. In the embodiment here shown, one of the rolls within the loop of wire F₁, i.e. roll 515A and two of the rolls within the loop of wire F₂, i.e. suction roll 519 and guide roll 516a are the driven rolls, however, other arrangements also provide satisfactory operation.

Accordingly, the instant forming arrangement provides a path of travel for a pair of opposed forming wires over a plurality of curved guide surfaces defining a bi-radii path of travel that substantially corresponds to the jet-stream trajectory at a slice chamber opening so that substantial amounts of natural drainage are allowed to take place, augmented by various other forces, i.e. centrifugal forces, gravity, vacuum, etc. to obtain efficient and fast dewatering of a forming web and that there is no second and/or reverse wrap in the path of travel of the wires carrying the web therebetween thereby avoiding detrimental wear of the wires or any possibility of web scuffing or the like. The forming system of the invention and particularly of the arrangement here shown, is capable of operations well above 3000 feet per minute for a variety of paper grades and it is extremely compact and easy to maintain, affording numerous advantages.

In summation, the invention provides a web forming system (preferably for use in paper formation) generally comprising a head box means for supplying a stream of web stock in a given direction, a pair of looped forming wires arranged to converge and provide an entrance nip for the reception of stock, means for supporting the wires within the respective loops and moving them into the entrance nip, curved guide elements positioned downstream and adjacent the entrance nip, within the loop of one of the wires so that the wires travel over a portion of the surfaces of the guide elements while having stock there-

between at a speed so that the stock is dewatered at least in part by centrifugal forces through one of the wires.

A specific preferred form of head box means comprises a stock supply means and a slice chamber means positioned in working relation with the supply means and with respect to the entrance nip of the forming wires. The slice chamber means has an outlet opening, first and second walls converging toward the outlet opening and a plurality of flexible trailing elements within the slice chamber arranged to define therebetween converging channels extending toward the outlet opening for guiding a dilute aqueous stock suspension therethrough as a suspension of entrangled co-moving fibers having a relatively low degree of turbulence and a relatively high degree of dispersion in a high speed, ribbon thin, substantially unidirectional, jet-like stream toward the outlet opening.

A specific preferred form of the curved guide elements comprises a stationary curved surface positioned adjacent the entrance nip and a rotary cylinder positioned downstream of the stationary surface so as to define therewith a continuous bi-radii curved path of wire travel having the first radius of curvature substantially larger than a second radius of curvature so that initially relatively gentle pressure is exerted on the stock between the wires and thereafter increased amounts of pressure are exerted on the stock. The stationary surface and rotating cylinder are arranged on the same side of the wires and have water-permeable or water-impermeable constructions. Also, the stationary curved surface has a relatively large radius of curvature, which is constant or decreasing in the direction of wire travel. In certain arrangements the rotary cylinder is provided with suction glands and functions as a couch roll in transferring the newly formed web away from the forming system.

The drawings and the specification present a detailed disclosure of the preferred embodiments mentioned and it is to be understood that the invention is not limited to the specific forms disclosed. Accordingly, it will be understood that modifications and variations may be effected without departing from the spirit and scope of the novel concepts of the present invention.

We claim as our invention:

1. An apparatus for forming fibrous webs comprising: first and second continuous looped foraminous forming wires which are arranged to converge and provide an entrance nip for the reception of web-forming stock;

a curved stationary surface positioned adjacent said entrance nip;

means for supporting said wires within their respective loops and moving said wires into said entrance nip; said forming wires being arranged to travel over said stationary curved surface downstream of said entrance nip while having stock therebetween,

a rotary cylinder,

said wires traveling around a part of the periphery of said rotary cylinder immediately following the stationary forming surface, with said surface and said cylinder being on the same side of said wires;

said stationary curved surface having a relatively large radius of curvature;

the first wire being free of restraining means on its outer surface opposite said rotating cylinder;

said wires arranged for traveling at a speed so that the stock is dewatered centrifugally through the first wire.

2. An apparatus as defined in claim 1 wherein the first wire passes over a roll for guiding it into said entrance nip.

3. An apparatus as defined in claim 2 including means for adjusting said roll relative to the entrance nip.

4. An apparatus for forming a fibrous web as defined in claim 1 wherein said wires wrap a guide roll after leaving the rotary cylinder with the first wire engaging said guide roll.

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5. An apparatus for forming fibrous webs as defined in claim 4 wherein the guide roll is a suction roll.

6. An apparatus for forming fibrous webs as defined in claim 4 including means for adjusting said roll relative to the rotary cylinder.

7. An apparatus for forming fibrous webs as defined in claim 1 including means for separating the first wire from the second wire following the rotary cylinder with the web being carried on the second wire.

8. An apparatus for forming fibrous webs as defined in claim 7 including a web transfer means positioned downstream of the rotary cylinder and in working relation with the second wire for transferring the web away from said second wire.

9. An apparatus for forming fibrous webs as defined in claim 8 including means forming a second sequence for forming a new ply of web over the web on the second forming wire comprising a third looped forming wire arranged to provide an entrance nip with the second forming wire after it has been separated from the first forming wire for the reception of stock on the surface of the web carried by the second forming wire, a curved stationary surface positioned adjacent said entrance nip, means for supporting said second and third wire within their respective loops and moving said second and third wires into said entrance nip, said second and third wires being arranged to travel over said stationary curved surface downstream of said entrance nip while having stock therebetween, a rotary cylinder, said second and third wires traveling around a part of the periphery of said rotary cylinder immediately following the stationary curved surface, with said stationary surface and said rotary cylinder being on the same side of the wires to support said second wire, said stationary curved surface having a relatively large radius of curvature, the third wire being free of restraining means on its outer surface opposite the rotary cylinder, said second and third wires arranged for traveling at a speed so that the stock is dewatered centrifugally through the third wire.

10. An apparatus for forming a fibrous web comprising:

first and second continuous looped foraminous forming wires which are arranged to converge and provide an entrance nip for the reception of web-forming stock; a curved stationary surface positioned adjacent said entrance nip;

means for supporting said wires within their respective loops and moving said wires into said entrance nip; said forming wires being arranged to travel over said stationary curved surface downstream of said entrance nip while having stock therebetween;

a rotary cylinder positioned downstream in close-working relation with said curved stationary surface to define a continuous bi-radii curved path of wire travel having a first radius of curvature substantially larger than a second radius of curvature;

said wires traveling around a part of the periphery of said rotary cylinder immediately following the stationary curved surface, with said stationary surface and said rotary cylinder being on the same side of said wires;

the first wire being free of restraining means on its outer surface opposite said rotary cylinder;

said wires arranged for traveling at a speed so that the stock is dewatered centrifugally through the first wire.

11. An apparatus for forming fibrous webs as defined in claim 10 wherein the curved stationary surface is a substantially water-permeable surface defined by a plurality of longitudinally spaced generally transverse wire-contacting relatively thin edges, the longitudinal contour of said wire-contacting edges defining the curve of said surface.

12. An apparatus for forming fibrous webs comprising: first and second continuous looped foraminous form-

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ing wires which are arranged to converge and provide an entrance nip for the reception of web-forming stock;

a curved stationary surface positioned adjacent said entrance nip;

means for supporting said wires within their respective loops and moving said wires into said entrance nip; said forming wires being arranged to travel over said stationary curved surface downstream of said entrance nip while having stock therebetween;

a rotary cylinder; said wires traveling around a part of the periphery of said rotary cylinder following the stationary surface with said stationary surface and said rotary cylinder being on the same side of said wires;

said curved surface being a substantial water-permeable surface defined by a plurality of longitudinally spaced generally transverse wire-contacting relatively thin edges, the longitudinal contour of said wire-contacting edges defining the curve of said water-permeable surface;

The first wire being free of restraining means on its outer surface opposite said rotary cylinder;

said wires arranged for traveling at a speed so that the stock is dewatered centrifugally through the first wire.

13. An apparatus for forming a fibrous web as defined in claim 12 wherein the wire-contacting thin edges are connected to a housing and means are connected to said housing for maintaining a subatmospheric pressure in the spacing between said wire-contacting thin edges for water removal through said spacing.

14. An apparatus for forming fibrous webs comprising, in combination:

first and second continuous looped foraminous forming wires which are arranged to converge and provide an entrance nip for the reception of web forming stock;

means for supporting said wires within their respective loops and moving said wires into said entrance nip; a stock supply means and a slice chamber means positioned in working relation with said stock supply means and with respect to said entrance nip;

said slice chamber having an outlet opening, a first and second wall converging toward said outlet opening and a plurality of flexible trailing elements within said slice chamber arranged to define therebetween converging channels extending toward said outlet opening and guiding a dilute aqueous stock suspension therethrough as a suspension of entangled co-moving fibers having a relatively low degree of turbulence and a relatively high degree of dispersion in a high-speed ribbon-thin substantially unidirectional jet-like stream toward said outlet opening;

a curved stationary surface positioned adjacent said entrance nip;

said forming wires being arranged to travel over said stationary curved surface downstream of said entrance nip while having stock therebetween;

a rotary cylinder positioned downstream with said curved stationary surface to define therewith a continuous bi-radii curved path of wire travel having a first radius of curvature substantially larger than a second radius of curvature;

said wires traveling around a part of the periphery of said rotary cylinder following the stationary curved surface, with said stationary surface and said rotary cylinder being on the same side of said wires;

the first wire being free of restraining means on its outer surface opposite said rotary cylinder;

said wires arranged for traveling at a speed so that the stock is dewatered centrifugally through the first wire, whereby initially relatively gentle pressure is exerted on the stock between the wires and thereafter increased amounts of pressure are exerted on said stock.

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15. An apparatus for forming fibrous webs as defined in claim 14 including means for adjusting the outlet opening of the slice chamber in relation to the entrance nip.

16. An apparatus for forming fibrous webs as defined in claim 14 wherein a stationary water-removing surface is positioned downstream of the rotary cylinder.

17. An apparatus for forming fibrous webs as defined in claim 14 wherein the curved stationary surface is defined by a relatively large radius of curvature for preventing substantially perpendicular pressure loading by the forming wires as they travel over said stationary surface.

18. An apparatus for forming fibrous webs as defined in claim 14 including means to orientate the slice chamber outlet so as to guide aqueous suspension of co-moving fibers generally upwardly in respect to the entrance nip whereby the aqueous suspension generally contacts the first wire before coming into contact with the second wire.

19. An apparatus for forming fibrous webs as defined in claim 18 including a web transfer means positioned downstream of the rotary cylinder in working relation with the second wire for transferring the web away from said second wire.

20. An apparatus for forming fibrous webs as defined in claim 14 wherein the rotary cylinder is a dewatering roll.

21. An apparatus for forming fibrous webs as defined in claim 20 wherein the dewatering roll is a foraminous roll.

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22. An apparatus for forming fibrous webs as defined in claim 21 wherein the foraminous roll is a suction roll.

23. An apparatus for forming fibrous webs as defined in claim 22 including means for separating the first wire from the second wire following the rotary cylinder with the web being carried on the second wire and a web transfer means positioned downstream of the rotary cylinder in working relation with the second wire for transferring the web away from said second wire.

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