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Justus
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[54] CONTROLLED FORMING WIRE SEPARATION ON IMPERVIOUS ROLL OF TWIN-WIRE PAPERMAKING MACHINE

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[52] **U.S. Cl.** **162/199;** 162/203; 162/274; 162/301; 162/343
[51] **Int. Cl.** **D21f 1/00**
[58] **Field of Search** 162/203, 301, 303, 306, 162/317, 318, 214, 199, 274, 343

[56] **References Cited**

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3,056,719	10/1962	Webster	162/203
3,201,305	8/1965	Webster	162/303 X
3,400,045	9/1938	Graham	162/214 X
3,531,371	9/1970	Jordansson et al.	162/318 X

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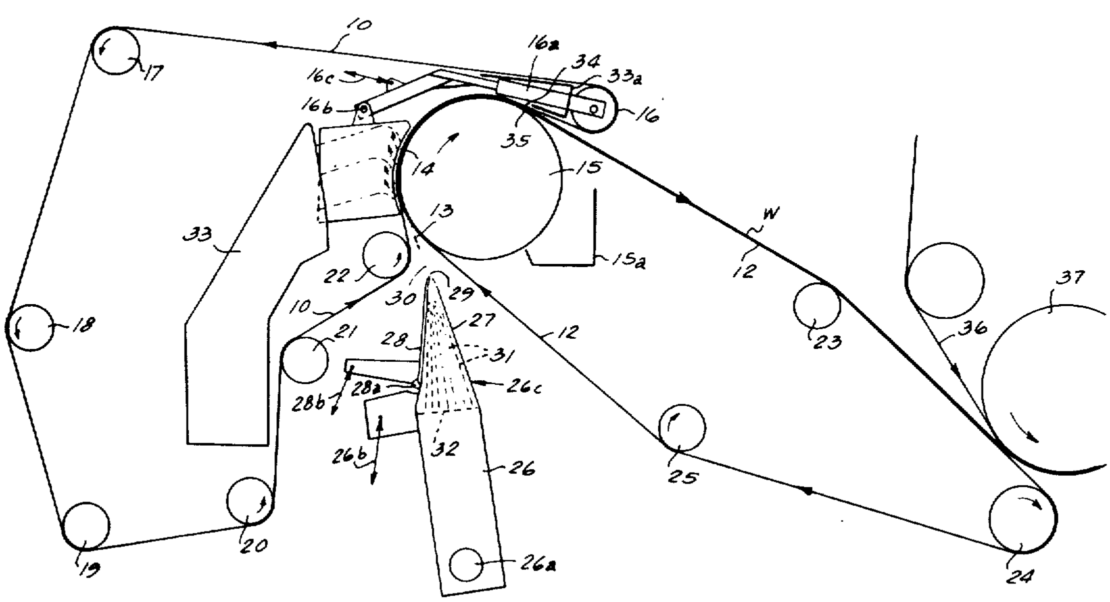
[57] **ABSTRACT**

A method and mechanism for continuously forming a fibrous web from a slurry of stock including first and second looped permeable woven forming wires positioned to travel over a solid impermeable roll and converge in a throat to travel through a forming run over the roll. A headbox chamber has trailing self-positionable elements therein and delivers stock to the forming throat. At the end of the forming run, the outer wire is separated from the inner wire at a separation point by a small angle α with the inner wire continuing on the roll for a short distance beyond said separation point. The outer wire will be cleaned at the separation point, and the web will uniquely follow the inner wire despite centrifugal force.

14 Claims, 3 Drawing Figures



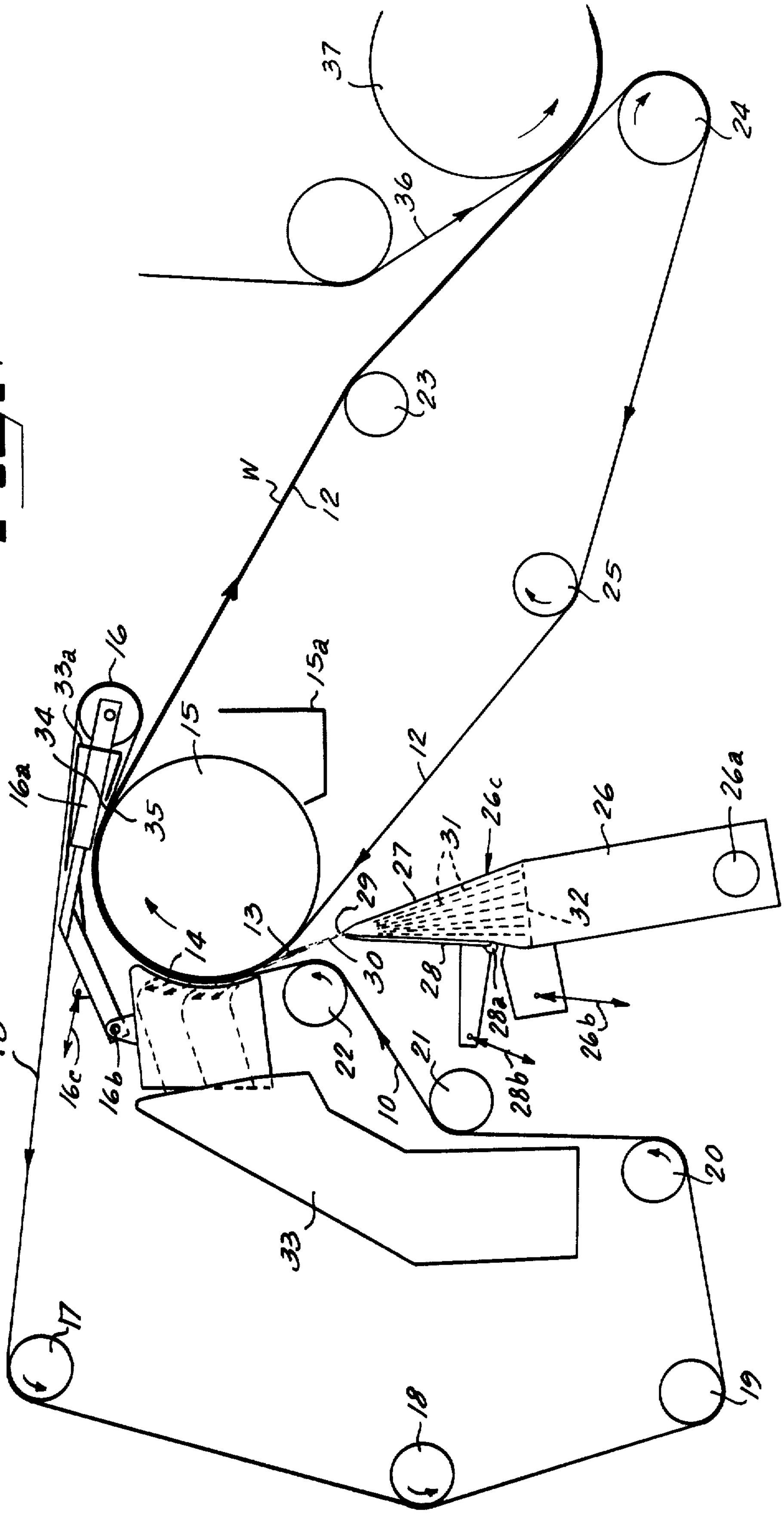

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FIG-1

Fig. 2

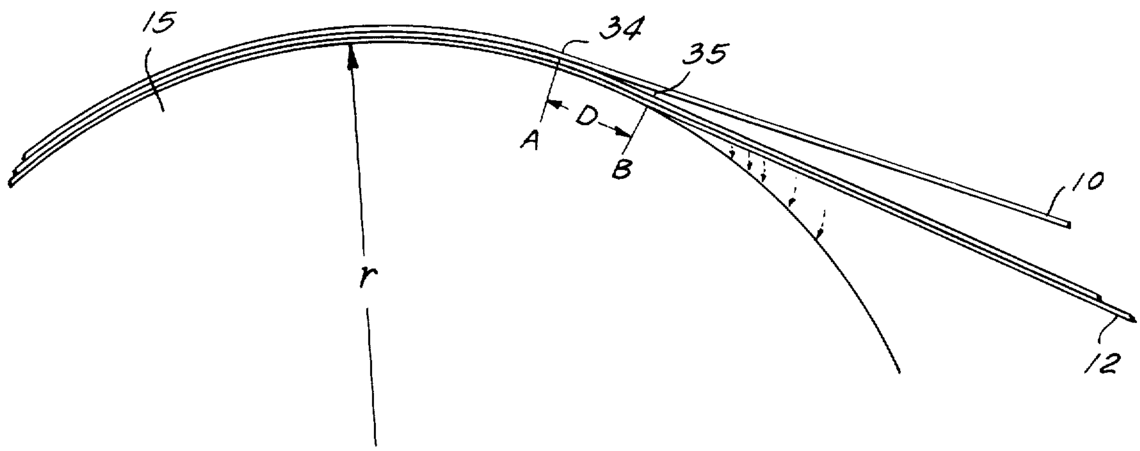
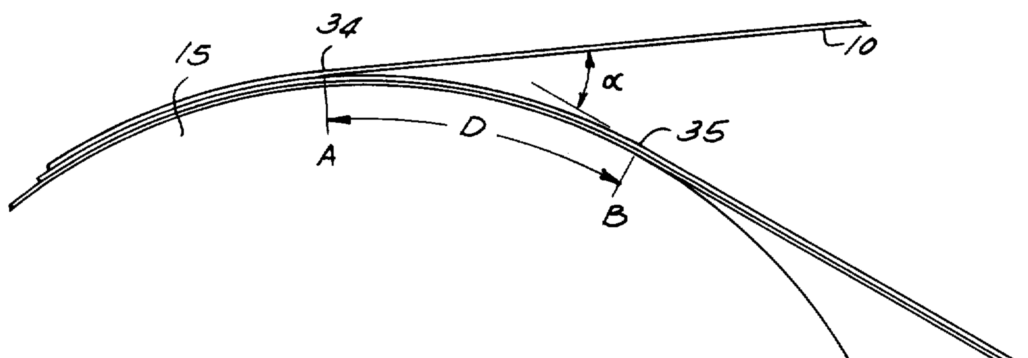


Fig. 3



CONTROLLED FORMING WIRE SEPARATION ON IMPERVIOUS ROLL OF TWIN-WIRE PAPERMAKING MACHINE

BACKGROUND OF THE INVENTION

The present invention relates to improvements in fibrous web formation wherein an aqueous fiber suspension is dewatered on a porous forming surface. More particularly, the invention relates to improvements in web forming mechanisms of the type which have become to be known to the art as twin wire formers wherein a slurry of fibrous stock is delivered from a headbox slice opening to a forming throat between a pair of looped traveling forming wires with the web dewatered by being squeezed between the forming wires.

In relatively recent developments the art of papermaking has undergone a number of significant advances in the field of paper web formation using two opposed forming wire runs for web formation therebetween as contrasted to the heretofore more conventional Fourdrinier type papermaking machine employing only a single forming wire. Such twin wire forming machines have met with commercial success offering advantages of requiring less space and improved dewatering at high speeds. As the speed of the papermaking machines are increased, it becomes increasingly difficult to handle and control a high speed traveling fibrous web and to determine with a certainty the continued position of the web and to insure that it will continue to follow a forming wire without leaving the forming wire surface or following an opposing wire. In the manufacture of light weight paper webs, such as tissue, it is increasingly difficult to insure that the paper is not damaged at the point of wire separation due to splitting of the web at that point and the problem is one of insuring that most of the fiber follows one or the other of the two forming wires. These problems are particularly presented in a twin wire forming machine wherein the wires must be separated in order to pick off the web, and the web must follow the exact wire which will carry it to a pickoff device.

Efforts to solve this problem have resulted in teachings of the art that a suction mechanism such as a suction box must be positioned within the wire which the web is to follow to insure that it is stapled or adhered to the wire just before or as the wires are separating. Where the twin wires pass over a roll in an upwardly extending forming run, the roll has been provided with a suction box to staple the web to the inner wire. The necessity of providing a suction gland and a hollow roll is undesirable in increasing initial construction cost and increasing power consumption. Another method which has been employed is to keep the wires together, but to pass one of the wires over a suction box to insure transfer of the web to that wire. An important disadvantage associated with structures of the type described above is that on light weight sanitary grades, such as tissue, the suction box surface damages the sheet even though such suction box is designed with great care. Also, the requirement for the provision of suction boxes or suction rolls requires additional cost and space for pumps and other ancillary parts that wear and require maintenance.

An example of teachings of the prior art is shown in U.S. Pat. No. 3,056,719, Webster, wherein the patentee solves the problems of the operation by either employing only a single forming wire with an additional

open roll and a suction gland at the end of the forming run to transfer the web to the wire, or, where two wires are used, providing an additional open roll with a suction box therein to assure adherence of the web to one of the wires.

Another teaching of the art is exemplified in U.S. Pat. No. 3,400,045, Graham, wherein the patentee requires that one of the flexible belts between which the web is sandwiched when it is formed be a felt, utilizing the commonly accepted teaching of the art that when two belts separate, the web will follow the belt of greater density, i.e., the felt.

A feature of the invention is applicant's discovery of a combination of elements so constructed and so arranged that it is possible to combine the advantages of a twin wire former with the economics of a plain roll, and the use of two woven mesh wires permitting operation at maximum speed so that the unit is capable of operation at speeds approaching 7,000 feet per minute which is unusually high in the operation of present-day machines. High speeds are accomplishable by utilizing woven wires for both the formation members along the forming run and passing them over a plain solid cylindrical roll which has an absence of suction glands and where the wires do not have to run over suction boxes. Contrary to previous teachings, applicant has discovered that by separation of the outer wire from the inner wire by a small angle α while the inside wire is still supported on the plain roll, the web will unerringly follow the inner wire regardless of centrifugal force and contrary to expectation if one follows the teachings of the prior art and as would be expected from observing the obviously high centrifugal forces. The phenomena of physical forces will position the web on the outer surface of the inner wire without it being stapled thereto for each pickoff and the mechanism discovered causes a cleaning of the outer wire removing fibers entrained or intermeshed with the outer wire due to the dewatering being effected through the outer wire during the forming run. At the end of the forming run, the outer wire is first led away from the inner wire at a very small angle, and the physical force of the vacuum created as the upper wire is separated from the solid roll, at speed, will cause a flow of air through the outer wire sweeping any water remaining in the outer wire inwardly to help clean the outer wire of fiber and water. The web is held to the inner wire by the dynamically created differential pressure across the web, created by the separation, at speed, of the outer wire from the roll while the inner wire is still wrapped on the roll. This separation, at speed, tends to create a void or vacuum between the two wires which can only be filled from outside the outer wire and cannot be filled from inside the inner wire because of the solid impervious surface of the roll. It is the filling of this void from the outside which creates the differential pressure which flushes the web and water from the outside surface of the inside wire. The vacuum or suction formed beneath the inner wire causes an inward flow of air and water through the outer wire so as to clean the outer wire and to help hold the web onto the inner wire. The surface tension of the water filling the interstices of the inner wire also causes the web to adhere to the inner wire, and in effect, the web is pasted onto the inner wire with a force which will completely overcome the centrifugal force on the web which tends to cause the web to lift off the inner wire. Using a woven inner wire and by pressing the web between the wires during the dewatering forming run, the removal of water will be substantially all through the outer wire. However, a small amount of water will travel inwardly to be held in the interstices of the inner wire to perform the sealing function which aids the phenomena of vacuum and surface tension thus insuring that the web will follow the inner wire. Since dewatering has occurred through the outer wire, the web will not be stapled to the inner wire, but will be resting lightly thereon so that it can readily be picked off the inner wire at the pickoff point and reducing the possibility of damage or splitting of the web.

An object of the present invention is to provide an improved and more economical twin wire forming mechanism and method using two woven wires with positive web control and the capability of having the web follow the inner wire without requiring suction boxes or suction rolls within the wire to effect the transfer of the web.

A further object of the invention is to provide an improved twin wire forming mechanism which is particularly well adapted to forming tissue or toweling and which utilizes simple high speed imperforate solid rolls for support of the twin wires.

A still further object of the invention is to provide a unique method and mechanism for the positive control of the web traveling in an arcuate path between a pair of forming wires insuring that the web follows the inner forming wire.

A further object is to provide a high speed paper forming system utilizing the dynamics of the woven forming wires and supports and without the use of externally powered vacuum devices such as suction rolls or suction boxes.

A further object of the invention is to provide a twin wire forming mechanism wherein the wires travel over a curved surface to dewater a web therebetween and dewatering is effected entirely through the outer wire and the outer wire is cleaned of fibers as the wires are separated and the web follows the inner wire.

The method and mechanism fine particular advantages in the formation of a paper web from cellulose fibers, but it will be understood that the features may be used to advantage in forming a web from other types of fibers. Also, the mechanism as disclosed is best suited for the handling of a slurry formed of an aqueous suspension but other forms of fluids may be employed.

Other objects, advantages and features, as well as equivalent structures and methods which are intended to be covered hereby will become more apparent with the disclosure of the preferred embodiment in the specification, claims and drawings in which:

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevational view shown in somewhat schematic form of a machanism constructed and operating in accordance with the principles of the present invention;

FIG. 2 is an enlarged fragmentary schematic view of a portion of the mechanism of FIG. 1 shown for the purposes of illustrating certain principles as will become clear from the description; and

FIG. 3 is another enlarged fragmentary schematic view illustrating an alternate form of operation of a mechanism embodying the principles of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

As shown in FIG. **1**, the mechanism includes first and second looped woven permeable forming wires **10** and **12**. The wires are trained over rolls so as to approach each other and form a tapered throat **13** into which a jet of stock is delivered, followed by an arcuate forming zone **14**. For defining the arc of the forming zone, the wires are wrapped over the arcuate outer surface of a plain cylindrical roll **15**. The roll has a smooth outer imperforate supporting surface for the wires, and the wires are tensioned so that they apply squeezing force normal to the web being formed therebetween to force the water out through the first or outer wire **10**. It is important that the second or inner wire **14** be a pervious woven wire so as to provide a web backing or support, which can receive but does not absorb or retain excess water and which does not require elaborate dewatering mechanisms itself for removal of its water, such as would be required for a felts.

It is also important to provide a wire for the inner support for the web so that its interstices hold water for sealing the underside of the web and pasting it onto the wire at the separation point with the wire providing a substantially noncompressible and nonexpansible web support.

Further, the wires **12** and **10** being substantially similar in openness or weave are particularly well adapted for the formation required for a given web such as tissue and toweling. The solid imperforate roll **15** is particularly well adapted to very high speed operation and eliminates the need for suction glands or suction means and eliminates necessity of rubbing surfaces. The mechanism as is shown which eliminates the need for the wire passing over suction boxes and eliminates the need for suction glands is capable of operating at uniquely high speeds on the order of up to 7,000 ft. per minute with satisfactory long wire life.

The elimination of suction glands and the elimination of the necessity for a hollow roll shell is significant in the ability of the mechanism to achieve unusually high operating speeds. The noise factor would create substantial problems at high speeds if a perforate suction roll were used and problems would vary likely exist providing sealing surfaces that could operate for any length of time at these high speeds. The problems of inertia and pressure waves exist when high speeds are encountered in that the periods of time to which the web or wire is subjected to pressure becomes unusually small. Also, as will be immediately recognized by those versed in the art, the initial cost of a plain roll is considerably lower and the driving power needed for operation is lower. Wire abrasion and wear are reduced and the pressure between wires and roll surface do not create the problems that are present when a perforate roll is used.

The first looped outer wire **10** is supported on rolls located within the wire shown at **16, 17, 18, 19, 20, 21** and **22**. At least one of the rolls, such as the roll **18** is capable of being moved to an adjusted position to place a predetermined linear tension in the wire to apply the desired squeezing force to the web in the forming zone **14**.

The second looped inner forming wire **12** is supported on rolls **23, 24** and **25**. The wires are both woven and preferably of the same size mesh.

As the water is squeezed from the web W which is being formed along the forming zone **14**, the water is thrown outwardly from the surface of the outer wire **10** to be caught by a saveall **33**. An additional saveall **33***a* is located when the outer wire is separated from the inner wire.

For delivering stock to the throat **13**, a headbox **26** is provided. Stock is delivered to the headbox under pressure to flow through the tapered slice chamber **26***a* of the headbox formed between the converging slice walls **27** and **28**. Slice wall **28** is preferably pivotally adjustable so as to controllably regulate the size of the slice opening **29** from which issues a stock jet **30**. The movable wall of the headbox is pivoted at **28***a*, and a power means shown schematically at **28***b* controls the pivotal position of the wall and hence the size of the slice opening **29**. The headbox **26** is supported on a pivot **26***a* and power means shown schematically at **26***b* and is attached to the headbox to establish its pivotal position. The pivotal position is chosen so that the stock jet **30** will substantially bisect the throat **13**, but adjustments can be made so that the jet **30** passes into the throat more or less tangential to either the inner wire **12** or the outer wire **10**.

A preferred form of headbox construction particularly well adapted to the formation of the web between wires, wherein the deflecting support for the wires is a solid roll, includes a plurality of trailing elements **31** positioned in the tapered slice chamber **30**. A fine scale turbulence is generated maintaining uniform fiber dispersion for dewatering through the outer wire. These trailing elements are anchored only at their upstream ends at a perforate wall **32** in the headbox and are positionable responsive solely to forces of the stock flowing through the slice chamber. The trailing elements **31** may be in the form on individual flexible strands of material such as plastic, or may be in the form of continuous or interrupted sheets extending across the headbox. These trailing elements divide the stock flow into a plurality of independent flows having small scale turbulence for intermixing and distribution of the fibers which form the web in the forming run.

The web W is formed in the forming zone **14**. As the wires are separated from the roll **15** and are separated from each other despite the fact that the outer wire is lifted first from the roll, the web follows the inner second wire **12**. The outer wire **10** is separated from the inner wire **12** at a separation point **34**, shown in FIGS. **1** and **2**.

The web W follows the wire **12** and is picked off the upper surface of the wire by pickoff felt **36** brought into close adjacency with the web by pickoff felt roll **37**. The web because it is dewatered through the outer wire, is not stapled to the inner wire but is easily removable.

The solid arcuate support for the wires in the forming zone is provided preferably by a cylindrical smooth surface roll **15**, but because of high attainable speeds and lack of wire to roll friction, it will be understood that other forms of supports may be used such as a curved shoe. It is important in the mechanism and method of the structure that the support be imperforate at the first separation point **34** where the outer wire **10** is separated from the inner wire **12** and at the second separation point **35** where the inner wire is separated from the roll.

By providing an imperforate smooth support for the inner wire at the first and second separation points **34** and **35**, the web is effectively sealed to the inner wire. It is also essential that the voids of the inner wire be filled with water so that the web will be sealed or pasted onto the inner wire. This is a result of the roll being imperforate and the web being squeezed during the forming run so that water which flows inwardly from the web fills the interstices of the inner wire. This will occur fairly easily in the forming zone and the rest of the water squeezed out of the web will be forced outwardly through the outer wire. Also, since the inner wire is filled with water, fibers will not be forced inwardly to staple themselves to the inner wire. Instead the web will be pasted to the inner wire and when the inner wire is lifted off the roll and the seal which holds the web to the inner wire is broken, the web can easily be lifted off the inner wire. When the inner wire reaches the separation points **34** and **35**, the surface tension of the water within the inner wire and the sealing effect of the solid roll pastes or holds the web to the inner wire. At the second separation point **35** when the inner wire is lifted off the roll, a vacuum tends to form beneath the inner wire drawing the web down against the inner wire and tending to draw the water out from the inner wire. This vacuum plus the surface tension between the water and the roll surface, will tend to cause the water in the interstices of the inner wire to follow the surface of the roll **15** when this water is thrown off the roll, it is caught by a saveall **15***a*. A separating doctor may be provided, not shown, to help the water separate from the outer surface of the roll **15** to pass into the saveall **15***a*.

Preferably, the outer wire **10** is separated on a very small distance from the inner wire **15** forming an acute angle α therebetween, as shown in FIG. **2**. The angle α should be kept as small as possible so that the distance D is small.

The dewatering run along the surface of the roll is of a length so that the web will be dewatered therealong and by the time the web reaches the top of the roll **15**, no substantial remaining amount of water is being squeezed therefrom. The amount of water squeezed from the web during the dwatering run is a function of the size of the roll as shown by the radius R of the roll **15** in FIG. **2**, and the linear tension of the outer wire **10**.

As illustrated in FIG. **1**, the supporting roll **16** for the outer wire **10** is adjustable in location so as to be able to selectively control the angle α between the outer and inner wires **10** and **12**. As illustrated somewhat schematically, the roll **16** is supported on a pivotal arm **16***a* pivotally supported at **16***b* and controllable in its position by a power means shown schematically at **16***c*. This permits moving the roll **16** through a range of positions to select an angle shown at α in FIG. **2** and at α' in FIG. **3**. A saveall **33***a* is positioned above the wire separation points **34** and **35**.

The angle α is preferably chosen to be at a minimum size such as in the range of greater than 0° and preferably not greater than 5°. With this arrangement, the vacuum formed at location **40**, FIG. **2**, and the surface tension between the water and roll surface will tend to draw the water from the inner wire **12** and paste the web W onto the wire so that centrifugal force will not lift it. The separation of the web from the outer wire will cause an inrush of air down through the outer wire **10** cleaning the wire. Because during forming dewatering has occurred only through the outer wire **10**, the wire has tended to become dirty because the fibers adhering to the wire. The inward flow of air and remaining adhering particles of water through the outer wire **10** cleans the wire. This cleaning is augmented by the inward surge of air tending to push forwardly any water present to cause a surge at location **41** to wash and help clean the upper wire removing the fibers stapled to the strands thereof. This surge of air through the outer wire is due to a large part to the inner wire being lifted off the roll with the inward pull on the web at that point. The operation shown in FIG. **3** lends support for this theory of outer wire cleaning because when the mechanism is operated in accordance with the relationship shown in FIG. **3** where the angle α is large, the outer wire **10** is not as well cleaned.

In the operation of FIG. **3**, the inner wire **12** is lifted off the roll a substantially greater distance D' after the point of first separation A'. Thus, the vacuum formed at point **40'** does not augment or act substantially simultaneously with, the vacuum formed at location **41'** so as to cause the inrush of air. It has been discovered, however, that some advantages of the invention are still obtainable with the operation of the arrangement of FIG. **3**. That is, the web will still be pasted to the inner wire **12**. As the outer wire **10** is lifted off of the roll, the web remains adhered to the inner wire due to the surface tension of the water in the interstices of the wire and due to the vacuum caused as the web tends to lift. As the wire **12** is lifted off of the roll from centrifugal force, the surface tension of the water causes the water in the wire to follow the roll. Because dewatering was substantially completely through the outer wire **10**, the web is not stapled to the inner wire **12** and rides lightly thereon making it relatively easy for a pickoff felt to pick the web off the wire.

Thus, in operation a stock from the headbox **26** is directed in a jet **30** into the throat **13** between the forming wires **10** and **12**. Along the forming run **14**, the web is dewatered through the outer wire **10** into the saveall **33**. At the end of the forming run, the outer wire **10** is first lifted off the roll and the inner wire **12** is almost immediately thereafter lifted off the roll **15**, and the physical effects of surface tension and vacuum create the phenomena of overcoming the centrifugal force on the web and cause it to adhere to the inner woven wire with a concurrent cleaning of the outer wire. The web resting on the inner wire is readily picked off the wire by a pickup felt.

I claim as my invention:

1. A mechanism for continuously forming a fibrous web from a slurry of stock comprising in combination:

a first looped permeable woven outer forming wire;

a second looped permeable woven inner forming wire; said wires positioned to form a converging throat leading to a forming run wherein the wires press against a web being formed therebetween;

a headbox having an opening positioned to direct a stream of stock into said throat;

guide rolls within each of the wire loops holding the loops in tension so that the outer wire applies a pressing force to press the stock between the wires in said forming run;

a convexly curved surface within the second wire with the first and second wires wrapping said surface along said forming run;

a first off running guide means for said first wire positioned following the forming run and separating the first wire from the second wire at a first separation point on said curved surface;

and a second off running guide means for said second wire following said forming zone and separating the second wire from said surface at a second separation point immediately following the first separation point with the web following the second wire;

said curved surface being imperforate at said separation points.

2. A mechanism for continuously forming a fibrous web from a slurry of stock constructed in accordance with claim **1**:

wherein said curved surface is the outer surface of a rotatable imperforate cylindrical roll supporting said wires through the forming run.

3. A mechanism for continuously forming a fibrous web from a slurry of stock constructed in accordance with claim **1**:

and including a saveall means positioned within the first wire adjacent the forming zone receiving water expressed from the web in the forming zone and discharged through the first wire.

4. A mechanism for continuously forming a fibrous web from a slurry of stock constructed in accordance with claim **1**:

wherein said second offrunning guide means is positioned so that the angle between the wires at the second separation point is in the range of 0° to 5°.

5. A mechanism for continuously forming a fibrous web from a slurry of stock constructed in accordance with claim **1**:

wherein said first and second wires each have a mesh of equal size.

6. A mechanism for continuously forming a fibrous web from a slurry of stock constructed in accordance with claim **1**:

including within the head box immediately upstream of the opening a tapered slice chamber with a plurality of flexible trailing members anchored only at their upstream ends and being self-positionable responsive to the pressure of stock flowing past said members.

7. A mechanism for continuously forming a fibrous web from a slurry of stock constructed in accordance with claim **1**:

including a traveling pick-up felt and a pick-up roll within the felt positioned to carry the felt in contact with the web on the second wire following said second separation point.

8. A mechanism for continuously forming a fibrous web from a slurry of stock constructed in accordance with claim **1**:

including means for adjusting the angle between the first and second wire following said separation points.

9. A mechanism for continuously forming a fibrous web from a slurry of stock comprising in combination:

a first looped permeable woven outer forming wire;

a second looped permeable woven inner forming wire with said wires positioned to form a converging throat leading to a forming run wherein a web formed between the wires is pressed and dewatered;

a slice means having an opening positioned to direct a stream of stock into said throat;

a roll having an imperforate outer surface over which the wire loops are wrapped through said forming run;

first guide means for the outer wire bending the outer wire over said roll throughout the forming run and lifting the outer wire off of the roll,

and second guide means for the inner wire training the inner wire on the roll for the forming run and lifting the inner wire off the roll immediately after the outer wire is separated therefrom so that the web will follow the inner wire.

10. The method of continuously forming a fibrous web from a slurry of stock which comprises:

passing a pair of looped perforate woven tensioned forming wires through an arcuate forming run over an arcuate surface to apply a force normal to a web being formed therebetween to dewater the web;

delivering a stream of fibrous stock to the upstream end of said forming run;

separating the outer wire from the inner wire at a first separation point while traveling through said arcuate run and separating the inner wire from said run at a second separation point immediately after said first point;

and blocking the inner surface of the inner wire so that fluid is prevented from flowing outwardly at said separation points so that the web follows said inner wire.

11. The method of continuously forming a fibrous web from a slurry of stock in accordance with the steps of claim **10**:

maintaining the wires at an angle of separation between greater than 0° and less than 5° after said separation points.

12. The method of continuously forming a fibrous web from a slurry of stock in accordance with the steps of claim **10**:

wherein said blocking of the inner surface of the wire is performed by supporting the inner wire on a rotatable cylindrical roll.

13. The method of continuously forming a fibrous web from a slurry of stock in accordance with the steps of claim **10**:

including the step of subsequently picking the web off of the inner wire after it has traveled a distance on the inner wire of said separation point.

14. The method of continuously forming a fibrous web from a slurry of stock which comprises:

guiding a pair of looped perforate woven forming wires under tension through an arcuate forming run over an imperforate rotating roll to apply a force normal to the web being formed therebetween to press water from the web into the space between the inner wire and the roll within interstices of the wire and through the outer wire so that water is thrown therefrom;

delivering a stream of fibrous stock slurry to the upstream end of the forming run;

and separating the outer wire from the inner wire lifting it off of the curved arcuate path on the roll while maintaining the inner wire on the roll so that the web remains pasted thereto and immediately thereafter lifting the inner wire off the roll so that the separation of the wires from each other and the inner wire from the roll generates an inward surge of air through the outer wire to clean fibers from the outer wire left thereon from dewatering through the outer wire.

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