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Bates

[11] 3,926,716
[45] Dec. 16, 1975

[54] TRANSFER AND ADHERENCE OF RELATIVELY DRY PAPER WEB TO A ROTATING CYLINDRICAL SURFACE

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[73] Assignee: The Procter & Gamble Company, Cincinnati, Ohio

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[51] Int. Cl.^{2} B31F 1/12
[58] Field of Search 162/111, 113, 112, 164, 162/206, 168; 161/128

[56] References Cited

UNITED STATES PATENTS

3,301,746	1/1967	Sanford et al.	162/113
3,812,000	5/1974	Salvucci	162/164

OTHER PUBLICATIONS

Casey "Pulp & Paper," Vol. II (1960) p. 1141.

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[57] ABSTRACT

In manufacturing a soft and absorbent tissue paper, a moist web deposited from a fiber-water slurry, is contoured with the pattern from an open mesh conveying fabric and thermally dried to a relatively high fiber consistency. Following these steps, the resulting relatively dry patterned web is imprinted as it is transferred and adhered to a rotating cylindrical surface in the form of a Yankee dryer utilizing an aqueous polyvinyl alcohol solution where the polyvinyl alcohol is characterized by a particular degree of hydrolysis and particular viscosity characteristics. By thermally drying to a high fiber consistency prior to the transfer step, the amount of drying load required to be carried by the Yankee dryer is reduced resulting in either (1) increased line speed as a result of reduced Yankee drying load, which reduces the required residence time of the web on the dryer or (2) a reduction in the required diameter of the Yankee dryer, a significant reduction in capital equipment cost. By thermally drying the web to a relatively high consistency on the conveying fabric, a deeper more pronounced pattern in the Z direction is obtained due to an increase in web structure strength and resistance to compaction of the pattern. This results in increased bulk (lower density) and increased softness. As a result of utilizing the particular polyvinyl alcohol, transfer and adherence of the relatively dry web to the Yankee dryer is obtained so as to minimize the amount of skipped crepe whereby the problem of web breakage downstream of creping is eliminated.

32 Claims, 4 Drawing Figures

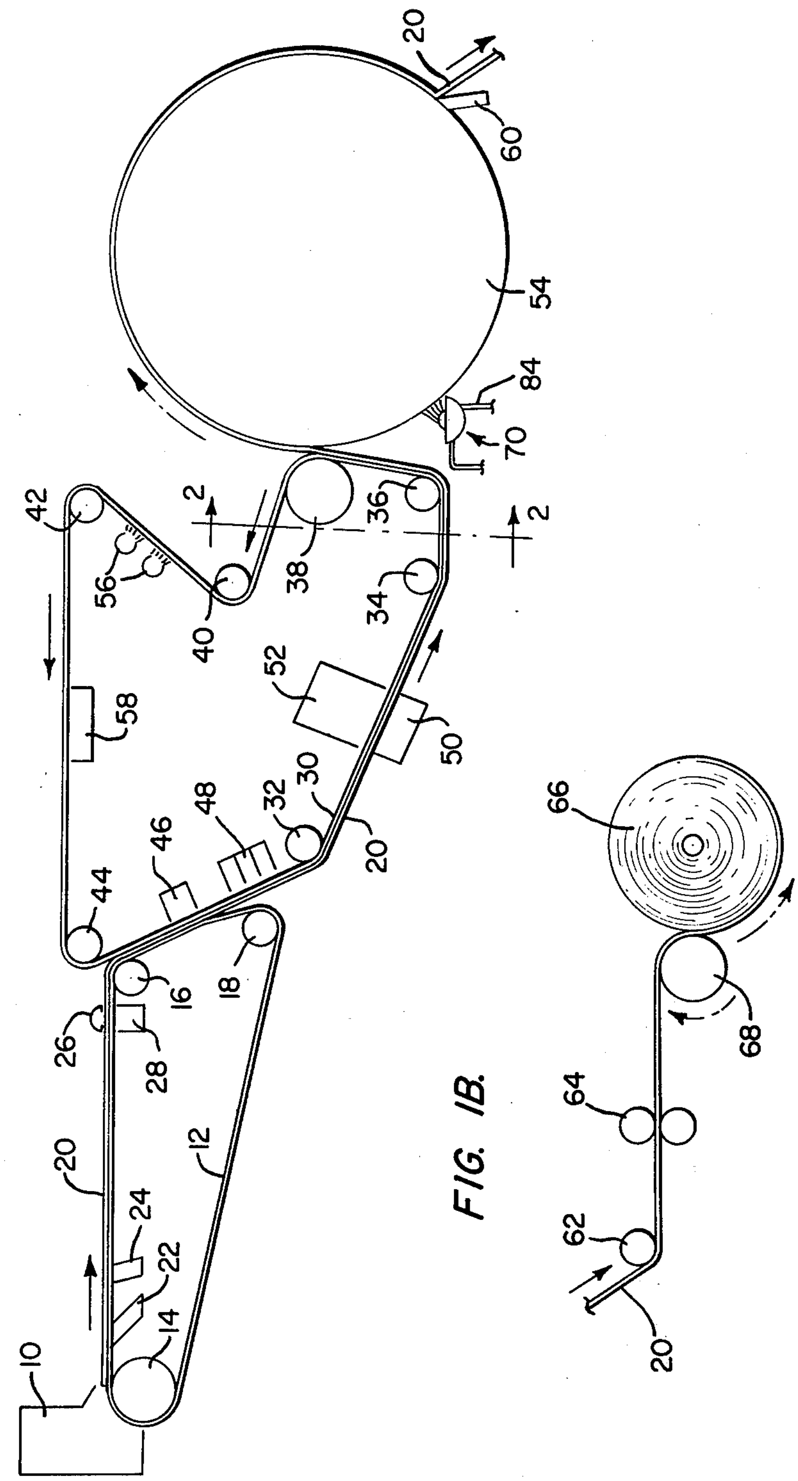
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FIG. 1A.

FIG. 1B.

FIG. 2.

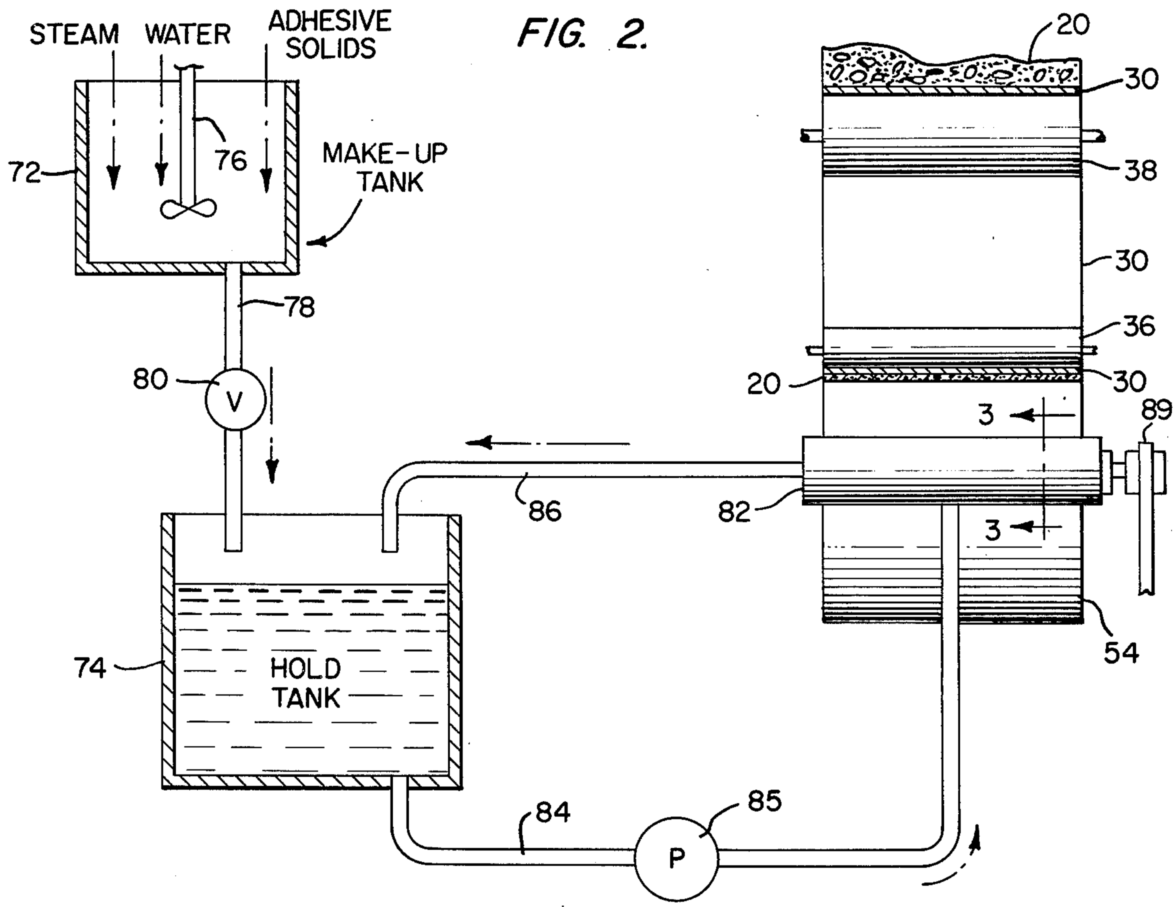
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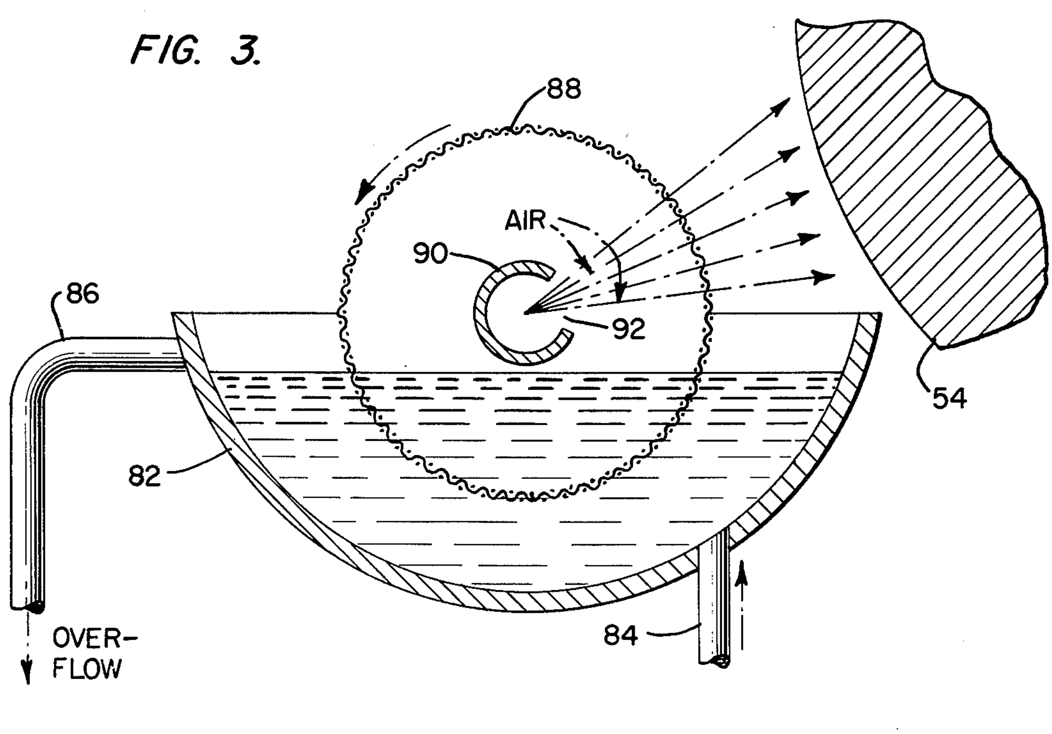
FIG. 3.


88
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OVER-FLOW

TRANSFER AND ADHERENCE OF RELATIVELY DRY PAPER WEB TO A ROTATING CYLINDRICAL SURFACE

BACKGROUND OF THE INVENTION

This invention relates to the manufacture of a soft and absorbent paper web especially suitable for use in tissue, towelling and sanitary products.

More particularly, this invention relates to a manufacturing process where a moist web is carried on an open mesh conveying fabric and is thermally dried. The thermally dried web is imprinted with the conveying fabric pattern as it is transferred and adhered to a rotating cylindrical surface in the form of a Yankee dryer. This type of process is disclosed in Sanford et al. U.S. Pat. No. 3,301,746, commonly owned by the assignee of the present invention.

It has been discovered that drying the paper web to a relatively high consistency prior to imprinting is advantageous, and the more thorough that drying is, the more significant the advantages that are achieved. In the present context the term "imprinting" is intended to mean the impression of the fabric imprinted into the web at the time of its transfer to the Yankee dryer. It is recognized that some fabric pattern impression is imparted to the moist paper web while being carried on the fabric but this is not to the same degree or extent which occurs in the imprinting step when the web is transferred to the Yankee dryer.

To particularize these advantages, it is noted that increasing the thermal drying of the web prior to its transfer to the rotating cylindrical surface allows a reduction in the Yankee drying load; and this allows an increase in line speed, since the amount of time required by the rotating cylindrical surface to provide the final fiber consistency is line speed limiting. And if thermal drying is carried out to higher web consistencies prior to transfer to the rotating cylindrical surface, not only is line speed increased, but a smaller diameter Yankee dryer can be used, resulting in significant savings in equipment costs.

Besides providing processing and equipment advantages, drying to a relatively high degree prior to transfer to the rotating cylindrical surface provides product advantages. In particular, the drier the web is at the time of transfer, the more permanent is the fabric impression in the Z direction, that is in the direction perpendicular to the web major surfaces, in other words, a more distinct and deeper impression is obtained. This improved impression results in greater bulk (lower density) and increased softness.

However, drying the web to relatively high fiber consistencies prior to transfer to the rotating cylindrical surface to obtain the above advantages can result in a problem in transferring and adhering the relatively dry web to the cylindrical surface. In particular, when the conventional animal glue disclosed at column **10**, lines **23–29** of the Sanford et al. patent is utilized in an attempt to improve the bond between the imprints and a Yankee dryer surface, a problem of insufficient bonding is noted when the web to be transferred has an average fiber consistency exceeding about 68%. As a result of this insufficient bonding, very few imprints are in contact with the Yankee dryer so that the web is not uniformly dried, and this non-uniformly dried state in conjunction with the insufficient bonding results in a very irregular crepe (that is, an excessive amount of

skipped crepe). This very irregular crepe results in a significantly increased web breakage problem in the processing sequence downstream of creping, especially in the processing sequence between the creping blade and the calendar stack. This web breakage problem becomes more severe as the fiber consistency of the web to be transferred is increased. When the fiber consistency of the web being transferred exceeds about 80%, the adherence with the animal glue is to poor that the resulting crepe has such irregularity that the web breaks in substantially every instance and the resulting product has poor softness characteristics.

The present invention is concerned with obtaining the advantages resulting from drying to a relatively high consistency during intermediate drying without the web breakage disadvantage occurring, which results from insufficient bonding of imprints to the rotating cylindrical surface upon which the subsequent creping step takes place.

With this in mind, consideration was given to the use of adhering agents other than the composition specifically described in Sanford et al. Several classes of polymeric materials were considered of which polyvinyl alcohols were preferred. It has been discovered that only particular polyvinyl alcohols are operative to obtain the advantages resulting from drying to a relatively high consistency prior to transfer to the rotating cylindrical surface while entirely eliminating the breakage problem which occurs upon the use of the above described animal glue composition. The present invention is concerned with the selection and definition of these particular advantageous polyvinyl alcohols.

The objects and advantages of the invention will be evident from the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1A** and **1B** schematically illustrate a papermaking process where the instant invention is applicable. FIG. **1B** follows FIG. **1A** in the processing sequence.

FIG. **2** is a view taken at line **2—2** of FIG. **1A** and illustrates the portion of the process concerning the make-up and use of adhering agent solution.

FIG. **3** is a view taken at line **3—3** of FIG. **2** depicting details of apparatus for applying adhering agent solution to a Yankee surface.

DETAILED DESCRIPTION

With continuing reference to FIGS. **1A** and **1B**, a papermaking furnish is delivered from a closed headbox **10** to a Fourdrinier wire **12**.

The Fourdrinier wire **12** is supported by breast roll **14** adjacent to headbox **10** and couch roll **16** which is spaced from and horizontally aligned with breast roll **14**. It follows a travel path defined by breast roll **14**, couch roll **16**, and return roll **18** which is spaced downwardly and vertically offset from couch roll **16**. The Fourdrinier wire **12** in following the travel path established by rolls **14**, **16** and **18** passes over roll **14**, then moves horizontally toward roll **16**, then passes over roll **16** and moves downwardly, then turns around and under roll **18**, then moves toward roll **14** and passes around and over roll **14**.

The headbox **10** forms a paper web **20** on the Fourdrinier wire **12** having a dry basis weight ranging for example from about 5 to about 40 pounds per 3000 square feet and an initial fiber consistency ranging for example from about 0.1% to about 0.3%. The formed web travels along the Fourdrinier wire 12 between breast roll 14 and couch roll 16 and continues along with Fourdrinier wire 12 during a portion of its path between couch roll 16 and return roll 18.

Forming devices 22 and 24 positioned near breast roll 14 respectively and successively bear on the underside of Fourdrinier wire 12 to remove water from the web 20.

Trimming nozzles 26 may be positioned downstream of forming device 24 to trim the sides of the web.

A suction box 28 is positioned under the Fourdrinier wire 12 adjacent couch roll 16 so as to draw water from the web 20 through wire 12.

As a result of the action of the forming devices 22 and 24 and the suction box 28, the web is dewatered to provide a fiber consistency ranging for example from about 10% to about 25%.

As the Fourdrinier wire 12 is in the portion of its travel path between couch roll 16 and return roll 18, the partially dewatered web 20 is transferred to the conveying and imprinting fabric 30.

The fabric 30 follows a travel path defined by a guide roll 32, a guide roll 34, a guide roll 36, a pressure roll 38, a guide roll 40, a guide roll 42 and a guide roll 44. The fabric in following this travel path passes under guide roll 32, then moves in a direction diagonally downwardly away from wire 12, then passes under guide roll 34, then moves substantially horizontally, then passes under guide roll 36 and turns upwardly therearound, then moves upwardly and passes over and around pressure roll 38, then moves back in the direction of Fourdrinier wire 12, then passes under and around guide roll 40, then moves diagonally upwardly in a direction away from Fourdrinier wire 12, then passes over and around guide roll 42, then moves substantially horizontally in a direction toward Fourdrinier wire 12, then passes over and around guide roll 44 at a location adjacent couch roll 16, then passes diagonally downwardly so as to be aligned with and adjacent the initial portion of the travel path of wire 12 between couch roll 16 and return roll 18, then passes under roll 32.

The conveying and imprinting fabric 30 has a mesh structure and is formed of filament so that when a vacuum is exerted to pull the moist web against the fabric, the web partially assumes the contour of the supporting surface of the fabric including its knuckle pattern. The fabric may be a woven polyester monofilament as described in U.S. Pat. No. 3,473,576 issued to John S. Amneus on Oct. 21, 1969 or it may have the characteristics of the fabric described in the application of Peter G. Ayers, Ser. No. 368,440, filed June 8, 1973, both said patent and said application being commonly owned by the assignee of the present invention. Preferably the fabric has its knuckle surfaces abraded away in accordance with the teachings of U.S. Pat. No. 3,573,164, issued Mar. 30, 1971 to Norman D. Friedberg et al, said patent being also commonly owned by the assignee of the present invention.

The transfer of the moist web from the Fourdrinier wire 12 to the fabric 30 is accomplished utilizing a vacuum box 46 positioned opposite fabric 30 between rolls 44 and 32. In this transfer the partially dewatered web is separated from the wire 12 and attaches to the fabric 30 and thereupon travels with fabric 30 through a portion of its travel path as described hereinafter.

A multi-stage vacuum box 48 is positioned on the side of fabric 30 opposite that in contact with web 20 at a location between transfer vacuum box 46 and guide roll 32. As depicted, the vacuum box 48 is a three-stage vacuum box containing compartments with the vacuum in each being independently adjustable. It functions to pull web 20 against fabric 30 so as to form a web conforming to the mesh pattern of the fabric.

As the web 20 travels along with fabric 30 between guide rolls 32 and 34 it is thermally dried. This drying is carried out without compacting the web. This is accomplished using a hot air drier 50 which is positioned on the same side of fabric 30 as is web 20 so as to direct hot air at the web 20. The hot air dryer 50 is preferably in the form illustrated and describd in U.S. Pat. No. 3,303,576 issued Feb. 14, 1967 to James B. Sisson, which patent is commonly owned by the assignee of the present invention. An exhaust fan 52 is positioned across from drier 50 on the opposite side of fabric 30 to remove moisture evaporating from the web. This drying is carried out to effect a fiber consistency in the web exceeding about 68% and ranging up to about 98%, that is to relatively high fiber consistencies. As previously explained, drying to these relatively high fiber consistencies prior to imprinting against the rotating cylindrical surface results in the obtainment of process advantages (lower thermal load on the Yankee dryer which allows increased line speed) and product advantages (increased softness and absorbency) compared to drying to a lesser extent previous to imprinting. The limitation of exceeding about 68% has been selected in this case because the adhering agent invention has unique advantage as explained previously with respect to webs dried previous to imprinting to that extent, namely the elimination of web breakage downstream of creping and more uniform cross direction moisture profiles. The upper limit of about 98% has been selected because at fiber consistencies exceeding this, overdrying of the sheet occurs which will diminish subsequent sheet control.

The web 20 having been subjected to thermal drying by the drier 50 continues along with fabric 30 until both reach pressure roll 38 whereupon web 20 is transferred to the rotating cylindrical surface of Yankee dryer 54.

As web 20 is being transferred to the rotating cylindrical surface of the Yankee dryer 54 it is also being imprinted with a knuckle pattern. This is effected by pressure roll 38 pressing web 20 and fabric 30 against the rotating cylindrical surface.

After the web 20 is transferred from fabric 30 to the rotating cylindrical surface, the fabric 30 having been freed of the web is washed with water sprays 56 and dried by a vacuum box 58 and then follows its travel path to pick up uncompacted web to be imprinted in the manner previously described.

The web 20 having been transferred to the rotating cylindrical surface is dried to final fiber consistency if not already at such consistency, whereupon it is creped from the surface by a doctor blade 60. While on a Yankee, the web is generally exposed to a temperature of at least 212°F. and usually not exceeding 350°F. The creped dried web then passes under a guide roll 62 and over a Mt. Hope roll (not depicted), then through a calender stack 64 and then is wound on take-up reel 66 which is driven by driving roll 68.

Turning now to the transfer of web 20 from fabric 30 to the rotating cylindrical surface of the Yankee dryer, the web is transferred with the aid of an aqueous solution of adhering agent which is sprayed on the rotating surface upstream of the point where the web is transferred to it. This adhering agent solution improves the bond between the imprints and the rotating cylindrical surface. In other words, adhering agent solution is applied to cause transfer and adherence of the imprinted web to a rotating cylindrical surface. The adhering agent solution application is generally denoted by numeral **70** on FIG. **1A.**

Turning now with particularity to the adhering agent application and with continuing reference to FIGS. **2** and **3,** the adhering agent application system comprises a make-up tank **72,** a hold tank **74,** an applicator described in detail later, and means for recirculating adhering agent solution between the hold tank and the applicator.

The make-up tank **72** is equipped with an agitator **76.** Provision is made for adding water and steam into tank **72** as indicated by arrows in FIG. **2.** The agitation and steam are to effect solution of adhering agent solids in water. The particular make-up procedure will be described in detail later. After the adhering agent solids have been dissolved in the water to make up the adhering agent solution, the made-up solution is passed by gravity flow via a pipe **78** equipped with a valve **80** to the hold tank **74.**

The hold tank **74** is in a recirculation loop with a trough **82** which is positioned adjacent the surface of Yankee dryer **54** upstream of the location where web **20** is to be transferred to that surface. The recirculation loop comprises a feed line **84** equipped with a pump **85** which communicates between the bottom of hold tank **74** and the bottom of trough **82** whereby adhering agent solution is fed from the bottom of hold tank **74** into trough **82.** The recirculation loop is completed by a return line **86** which provides communication between an overflow outlet in trough **82** and the open top of hold tank **74.** The overflow outlet in trough **82** coacts with the rest of the recirculation means and functions to establish a constant level of adhering agent solution in trough **82** as indicated in FIG. **3.**

A device for applying adhering agent solution to the rotating cylindrical surface is particularly disclosed in FIG. **3** and it includes the trough **82.** It also includes a rotating cylindrical foraminous member **88** axially aligned with the long dimension of the trough and with the surface of the Yankee **54** and positioned so that a portion of it extends below the upper level of the adhering agent solution in trough **82.** The foraminous member **88** is adapted to be rotated by means **89** (FIG. **2**) so that a portion of its surface moves into the liquid in trough **82** and lifts liquid from the trough holding it in its interstices as a result of surface tension. A pipe **90** is coaxial with and positioned inside of the cylindrical foraminous member **88.** It contains a slot **92** positioned to direct air through member **88** in the direction of the rotating cylindrical surface of the Yankee **54** whereby adhering agent solution is carried from the interstices of member **88** and applied to the rotating cylindrical surface.

Having described a milieu for the invention, the instant invention is now turned to with particularlity. As previously explained, the invention herein resides in the selection and definition of the particular adhering agent which is applied. The preferred adhering agent for use herein is used in aqueous solution and is a polyvinyl alcohol characterized by a degree of hydrolysis ranging from about 80% to about 90% and a viscosity as a 4% aqueous solution at 20°C. exceeding about 20 centipoises. Preferably the polyvinyl alcohol is characterized by a degree of hydrolysis ranging from about 86% to about 90% and a viscosity as a 4% aqueous solution at 20°C. above about **35** centipoises. Polyvinyl alcohols having these properties are commercially available and particular polyvinyl alcohols are disclosed in terms of degree of hydrolysis and viscosity as a 4% aqueous solution at **20**°C. in a book entitled "Polyvinyl Alcohol" by C. Finch, published by John Wiley and Sons (New York 1973), a copy of which is in the Patent Office Scientific Library under number TP1180.V48.P55.

The aqueous solution which is applied herein desirably contains a concentration of the above described particular polyvinyl alcohol ranging from about 0.1% to about 1% by weight. The lower limit is related to the applicator design and is selected so that the applicator will be able to apply the correct amount of adhering agent to the rotating surface of the Yankee in the time available. The upper limit is selected so as to minimize the amount of adhering agent building up on the rotating cylindrical surface which in turn minimizes wear on the stripping means used to control such build-up.

The aqueous solution is applied to the rotating cylindrical surface to provide from about 0.05 pounds to about 2 pounds of polyvinyl alcohol (on a dry basis) per ton of paper produced (on a dry basis), preferably from about 0.3 to about 1 pound of polyvinyl alcohol (on a dry basis) per ton of paper produced (on a dry basis). If less than about 0.05 pounds per ton of paper (on a dry basis) is utilized, the adherence of the imprints to the rotating cylindrical surface may not be sufficient to obtain the advantages of the invention. If more than about 2 pounds of polyvinyl alcohol solids per ton of paper on a dry basis is utilized, the adherence can be so great that the doctor blade will have difficulty removing the paper.

Turning now with particularity to the method of adhering agent application depicted in FIGS. **2** and **3,** water is added into tank **72** and polyvinyl alcohol solids are added thereto with agitator **76** being run at high speed. After the solids have been thoroughly dispersed in the water steam is injected into the water to bring its temperature to a level usually ranging from about 160°F. to about 190°F. This temperature is maintained over a period of time ranging for example from about 30 minutes to about one hour by the periodic injection thereinto of steam. During the steam injection the agitation is slowed so as to minimize the possibility of foam production. As a result of this procedure the polyvinyl alcohol solids are dissolved in the water. At this point valve **80** is opened and the adhesive solution is drained into hold tank **74.** Pump **85** is then started to provide a level of adhering agent solution in trough **82** and a recirculation rate is provided between hold tank **74** and trough **82** ranging for example from about 0.5 gallons per minute to about 1.5 gallons per minute. Foraminous member **88** is rotated and air flow into nozzle **90** is effected. Preferably the air flow is maintained constant and the rate of application of adhering agent solution to the rotating surface is adjusted by adjusting the speed of rotation of the foraminous member **88.**

As a result of the selection of the adhesive constituent in accordance with the present invention the web **20** can be thermally dried previous to imprinting to a fiber consistency exceeding about 68% and ranging up to about **98%** without web breakage occurring downstream of creping. Conventional animal glues and other polyvinyl alcohols are disadvantageous in respect to web breakage at these fiber consistencies.

Inasmuch as this invention allows drying previous to imprinting to provide a relatively dry web, the process advantage described hereinbefore of reducing the drying load on the Yankee thereby allowing increase in line speed and the product advantage described hereinbefore of greater bulk and increased softness compared to where there is thermal drying to a lesser extend prior to imprinting are obtained.

This invention also allows the reduction in the diameter of the Yankee required thereby providing a significant reduction in equipment cost.

The product obtained herein from the above described process is a soft and absorbent tissue paper web. It can be characterized, for example, by having a uniform basis weight of about 5 to about 40 pounds per 3000 square feet. It has impressed in its surface the knuckle pattern and surface contour of the imprinting fabric. The obtained paper web has a relatively low bulk density compared to paper manufactured in a conventional tissue manufacturing process.

The inventive concepts herein are illustrated in the following specific example. In this example the system depicted in FIGS. **1A, 1B, 2** and **3** is utilized except that when the uncompacted web is dried to between 85% and 98% while on fabric **30**, a creping drum may be utilized in place of a Yankee dryer **54**.

EXAMPLE

A pulp slurry having 0.3% fiber consistency and containing 35% bleached northern softwood kraft and **65%** bleached poplar sulfite, prerefined at 3.5% consistency in a conventional conical pulp refiner at 100 kw.-hr./ton is distributed by the headbox which is of conventional hydraulic design. The Fourdrinier wire **12** is of polyester woven with **78** warp and **62** weft strands per inch moving continuously at **1000** f.p.m. Flow and Fourdrinier wire movement are regulated so that a uniform moist paper web, having a dry basis of 11.4 pounds per3000 square feet, is formed on the Fourdrinier wire. The forming devices **22** and **24** and the suction box **28** remove water from the web to provide a fiber consistency of **25%**. The suction box **28** contacts the underside of the Fourdrinier wire with a vacuum equivalent to 3 inches of Hg. The vacuum box **46** effects a vacuum of 8 psig to effect transfer of the uncompacted web from the Fourdrinier to the fabric **30.** The fabric **30** is woven with 36 warp strands per inch made of 0.016 inch diameter crimped polyester monofilament and 30 weft strands per inch similar to the warp strands, particularly in that they are crimped to the same degree, with a diameter of 0.016 inch. The three-stage box **48** is adjusted so that the first compartment which affects the web exposes it to a vacuum of 12 psig, the second compartment exposes the web to a vacuum of 12 psig and the third compartment exposes the web to a vacuum of **10** psig. The thermal dryer **50** supplies air at a temperature required to effect a fiber consistency prior to imprinting as indicated in the table below. The particular temperature utilized depends upon the fiber consistency desired to be achieved. A temperature of 380°F. is utilized to achieve the fiber consistency of 50% in the table below while a temperature of 520°F. is utilized to achieve the fiber consistency of 98% noted in the table below with the temperature regulated to levels between 380°F. and 520°F. to achieve fiber consistencies between **50%** and **98%**. The Yankee dryer has a diameter of 8 feet and a width of 31 inches. The dried uncompacted web is imprinted with a nip pressure at pressure roll 38 of 300 pounds lineal inch to imprint the web with the pattern of the imprinting fabric. Adhering agent solution is applied by applicator **70** at a point 12 inches upstream of the nip between roll **38** and the drum of Yankee **54** and it is applied in a pattern which extends circumferentially on the surface of Yankee **54** about 3 to 4 inches. Various polyvinyl alcohols are utilized as indicated in the table. All of the polyvinyl alcohols utilized are readily commercially obtainable from the Monsanto Chemical Company and others. In this example, of the polyvinyl alcohols utilized, Gelvatol 20–90 and Gelvatol 20–60 are within the scope of the invention. The other polyvinyl alcohols utilized, namely Gelvatol 1–90, Gelvatol 3–60, Gelvatol 20–30 and Gelvatol 1–30 are outside the scope of the invention. In relation to the Gelvatols the first stated number indicates the precentage residual polyvinyl acetate and the next series of digits when multiplied by 1,000 gives the number corresponding to the average molecular weight. As indicated in FIG. **2.1** of the book entitled "Polyvinyl Alcohol" by C. Finch described earlier, Gelvatol 20–90 has a degree of hydrolysis of about 88% and a viscosity as a **4%** aqueous solution at 20°C. of about 40 centipoises; Gelvatol 20–60 has a degree of hydrolysis of 86 to 87% and a viscosity as a 4% aqueous solution at 20°C. of slightly over **20;** Gelvatol 1–90 has a degree of hydrolysis from 99 to 100% and a viscosity of about 60 centipoises as a 4% aqueous solution at 20°C.; Gelvatol 3–60 has a degree of hydrolysis ranging from about 99 to 100% and a viscosity as a 4% aqueous solution at 20°C. of about 28–29 centipoises; Gelvatol 20–30 has a degree of hydrolysis of about 88% and a viscosity as a 4% aqueous solution at 20°C. of approximately **6** centipoises; Gelvatol 1–30 has a degree of hydrolysis ranging from about 99 to 100% and a viscosity as a 4% aqueous solution at 20°C. of approximately 4 to 5 centipoises. The animal glue referred to below is formulated from a 100% liquid animal glue. The Gelvatols and animal glue are applied as **1%** by weight aqueous solutions. The Gelvatol solutions are made up by introducing 100 liters of cold tap water into make-up tank **72** with agitator **76** operated at high speed. **1100** grams Gelvatol solids are then added. The high speed agitation is continued for 20 minutes. At this point steam is injected to bring the temperature of water to 180°F. The 180°F. temperature is maintained by the periodic injection of steam during a 45-minute period. During the steam injection the agitation is slowed to minimize foam formation. At this point sufficient water is added to obtain a **1%** weight concentration of adhering agent solids. The above procedure is sufficient to form an aqueous solution of the adhering agent solids. In the make-up of the animal glue solution, the liquid animal glue is added into cold water in tank **72** under slow agitation and steam is injected to heat the water to 140°F. whereupon the combination is held for 20 minutes under slow agitation. In each case the aqueous solution is pumped from hold tank **74** at a rate of **1** gallon per minute. Reticulated member **88** has a mesh of 30 × 28 and is constructed of stainless steel wire; it is 21 inches wide and 12 inches in diameter. Pipe **90** is 2 inches in diameter and the slot **92** has a width of 0.025 inch; 3 psig air is utilized. The rate of adhering agent application is at about 1 pound adhering agent (on a dry basis) per ton of paper (on a dry basis). The paper produced in all cases is very absorbent (Reid test of 7–9 seconds) and soft (at least equivalent to commercially available products), and the higher the fiber consistency prior to imprinting the better the absorbency and the softer the paper is. The following table presents a comparison of various adhering agent solutions used in conjunction with webs having various fiber consistencies as noted in the table prior to imprinting and indicates the advantage of the selected adhering agents of the instant invention over other adhering agents in respect to web breakage downstream of creping. In the following table, "0" denotes no breaks in a 24 hour period; "Few" denotes a few breaks in a 24 hour period; "Several" denotes several breaks in a 24 hour period; and "Continual" denotes breakage every time the web was attempted to be reeled up.

TABLE

ADHERING AGENT TYPE	FREQUENCY OF WEB BREAKAGE (TIMES IN A 24 HOUR PERIOD) FIBER CONSISTENCY PRIOR TO IMPRINTING (PERCENT)					
	50	60	70	80	90	98
Gelvatol 20–90*	0	0	0	0	0	0
Gelvatol 20–60*	0	0	0	0	0	0
Gelvatol 1–90**	0	0	Few	Several	Continual	Continual
Gelvatol 3–60**	0	0	Few	Several	Continual	Continual
Animal Glue**	0	0	Few	Several	Continual	Continual
Gelvatol 20–30**	0	Few	Several	Continual	Continual	Continual
Gelvatol 1–30**	Continual	Continual	Continual	Continual	Continual	Continual

*within scope of invention
**outside scope of invention

As indicated by the above table web breakage downstream of creping is entirely eliminated even at fiber consistencies prior to imprinting as high as 98% when polyvinyl alcohols within the scope of the invention are utilized. On the other hand when other polyvinyl alcohols or animal glues are utilized there is at least some web breakage at fiber consistencies prior to imprinting greater than about 68%. The above table clearly indicates the advantage of the present invention over the use of other adhering agents when fiber consistencies prior to imprinting greater than about 68% are utilized.

While not wishing to be bound to any theory, it is speculated that the better adherence obtained by utilizing polyvinyl alcohols in accordance with the invention is obtained due to surface tension adhesion and hydrogen bonding supplied by the water solution of polyvinyl alcohol which is held as a film against the rotating drying cylinder and the polyvinyl alcohols of the invention act as a means for retaining the water at the rotating drum surface. This would explain why the polyvinyl alcohols that are operative have relatively low degrees of hydrolysis. It would also explain why higher fiber consistencies prior to imprinting are more difficult to transfer; this would probably be because there would not be enough surface water in the web so that the surface tension adhesion and hydrogen bonding mechanism could come into play. It is speculated that polyvinyl alcohols of medium high and high viscosity are required because these have a stable viscosity at the temperatures at the surface of the Yankee.

The fiber consistencies herein are average fiber consistencies.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. For example, the particular polyvinyl alcohols selected and defined above have use in providing adherence between a web and a rotating cylindrical surface without web breakage occurring downstream of creping in papermaking processes other than the one particularly depicted in the Figures of the drawing as long as the process involves thermally drying without compacting a moist web to a fiber consistency exceeding about 68% and ranging up to about 98%, imprinting the resulting relatively dry web with a pattern and transferring and adhering the imprinted web to a rotating cylindrical surface in the form of a Yankee dryer where the web is dried to final fiber consistency (if not already at that consistency) and creped. For example, the papermaking process can be one in which the web forming carrier and the conveying and imprinting fabric are one and the same. Moreover, the adhering agent solution can be applied in ways other than that specifically described, for example utilizing spray nozzles, separate water and glue sprays, etc. In view of the variations that are readily understood to come within the limits of the invention, such limits are defined by the scope of the claims.

I claim:

1. A process for manufacturing a soft and absorbent tissue paper web having a uniform basis weight of about 5 to about 40 pounds per 3000 square feet, said process comprising the steps of

a. drying without compacting a moist paper web to provide a fiber consistency exceeding about 68% and ranging up to about 98% while said web is on a patterned imprinting fabric;

b. imprinting the resulting relatively dry web with the pattern of the imprinting fabric;

c. applying an aqueous polyvinyl alcohol solution to cause transfer and adherence of the imprinted web to a rotating cylindrical surface, said polyvinyl alcohol being characterized by a degree of hyrolysis ranging from about 80% to about 90% and a viscosity as a 4% aqueous solution at 20°C. exceeding about 20 centipoises.

2. A process as recited in claim **1**, in which said polyvinyl alcohol is characterized by a viscosity as a 4% aqueous solution at 20°C. above about 35 centipoises.

3. A process as recited in claim **2**, in which said polyvinyl alcohol is characterized by a degree of hydrolysis ranging from about 86% to about 90%.

4. A process as recited in claim **3**, in which the rotating cylindrical surface is a Yankee dryer surface.

5. A process as recited in claim **1**, in which the rotating cylindrical surface is a Yankee dryer surface.

6. A process as recited in claim **5**, in which said polyvinyl alcohol is characterized by a viscosity as a 4% aqueous solution at 20°C. above about 35 centipoises.

7. A process as recited in claim **1**, in which said polyvinyl alcohol solution is applied to provide an amount of polyvinyl alcohol on a dry basis ranging from about 0.05 pounds to about 2 pounds per ton of paper on a dry basis.

8. A process as recited in claim **7,** in which said polyvinyl alcohol solution is applied to provide an amount of polyvinyl alcohol on a dry basis ranging from about 0.3 pounds to about 1 pound per ton of paper on a dry basis.

9. A process for manufacturing a soft and absorbent tissue paper web having a uniform basis weight of about 5 to about 40 pounds per 3000 square feet, said process comprising the steps of

a. causing a moist paper web to conform to the pattern of a patterned imprinting fabric utilizing vacuum and then drying the moist web on the fabric without compacting to provide a fiber consistency exceeding about 68% and ranging up to about 98%;
b. imprinting the resulting relatively dry web with the pattern of the imprinting fabric by use of roll pressure;
c. applying an aqueous polyvinyl alcohol solution to cause transfer and adherence of the imprinted web to a rotating cylindrical surface, said polyvinyl alcohol being characterized by a degree of hydrolysis ranging from about 80% to about 90% and a viscosity as a 4% aqueous solution at 20°C. exceeding about 20 centipoises.

10. A process for manufacturing a soft and absorbent tissue paper web having a uniform basis weight of about 5 to about 40 pounds per 3000 square feet, said process comprising the steps of

a. drying a moist paper web to provide a fiber consistency exceeding about 68% and ranging up to about 98% while said web is on a patterned imprinting fabric without utilizing roll pressure to compact the web;
b. imprinting the resulting relatively dry web with the pattern of the imprinting fabric by use of roll pressure;
c. applying an aqueous polyvinyl alcohol solution to cause transfer and adherence of the imprinted web to a rotating cylindrical surface, said polyvinyl alcohol being characterized by a degree of hydrolysis ranging from about 80% to about 90% and a viscosity as a 4% aqueous solution at 20°C. exceeding about 20 centipoises.

11. A process for manufacturing a soft and absorbent tissue paper web having a uniform basis weight of about 5 to about 40 pounds per 3000 square feet, said process comprising the steps of

a. drying a moist paper web to provide a fiber consistency exceeding about 68% and ranging up to about 98% while said web is on a patterned imprinting fabric by directing hot air at the web;
b. imprinting the resulting relatively dry web with the pattern of the imprinting fabric;
c. applying an aqueous polyvinyl alcohol solution to cause transfer and adherence of the imprinted web to a rotating cylindrical surface, said polyvinyl alcohol being characterized by a degree of hydrolysis ranging from about 80% to about 90% and a viscosity as a 4% aqueous solution at 20°C. exceeding about 20 centipoises.

12. A process as recited in claim **9,** in which said polyvinyl alcohol is characterized by a viscosity as a 4% aqueous solution at 20°C. above about 35 centipoises.

13. A process as recited in claim **12,** in which said polyvinyl alcohol is characterized by a degree of hydrolysis ranging from about 86% to about 90%.

14. A process as recited in claim **13,** in which the rotating cylindrical surface is a Yankee dryer surface.

15. A process as recited in claim **9,** in which the rotating cylindrical surface is a Yankee dryer surface.

16. A process as recited in claim **15,** in which said polyvinyl alcohol is characterized by a viscosity as a 4% aqueous solution at 20°C. above about 35 centipoises.

17. A process as recited in claim **16,** in which said polyvinyl alcohol solution is applied to provide an amount of polyvinyl alcohol on a dry basis ranging from about 0.05 pounds to about 2 pounds per ton of paper on a dry basis.

18. A process as recited in claim **17,** in which said polyvinyl alcohol solution is applied to provide an amount of polyvinyl alcohol on a dry basis ranging from about 0.3 pounds to about 1 pound per ton of paper on a dry basis.

19. A process as recited in claim **10,** in which said polyvinyl alcohol is characterized by a viscosity as a 4% aqueous solution at 20°C. above about 35 centipoises.

20. A process as recited in claim **19,** in which said polyvinyl alcohol is characterized by a degree of hydrolysis ranging from about 86% to about 90%.

21. A process as recited in claim **20,** in which the rotating cylindrical surface is a Yankee dryer surface.

22. A process as recited in claim **10,** in which the rotating cylindrical surface is a Yankee dryer surface.

23. A process as recited in claim **22,** in which said polyvinyl alcohol is characterized by a viscosity as a 4% aqueous solution at 20°C. above about 35 centipoises.

24. A process as recited in claim **23,** in which said polyvinyl alcohol solution is applied to provide an amount of polyvinyl alcohol on a dry basis ranging from about 0.05 pounds to about 2 pounds per ton of paper on a dry basis.

25. A process as recited in claim **24,** in which said polyvinyl alcohol solution is applied to provide an amount of polyvinyl alcohol on a dry basis ranging from about 0.3 pounds to about 1 pound per ton of paper on a dry basis.

26. A process as recited in claim **11,** in which said polyvinyl alcohol is characterized by a viscosity as a 4% solution at 20°C. above about 35 centipoises.

27. A process as recited in claim **26,** in which said polyvinyl alcohol is characterized by a degree of hydrolysis ranging from about 86% to about 90%.

28. A process as recited in claim **27,** in which the rotating cylindrical surface is a Yankee dryer surface.

29. A process as recited in claim **11,** in which the rotating cylindrical surface is a Yankee dryer surface.

30. A process as recited in claim **29,** in which said polyvinyl alcohol is characterized by a viscosity as a 4% aqueous solution at 20°C. above about 35 centipoises.

31. A process as recited in claim **30,** in which said polyvinyl alcohol solution is applied to provide an amount of polyvinyl alcohol on a dry basis ranging from about 0.05 pounds to about 2 pounds per ton of paper on a dry basis.

32. A process as recited in claim **31,** in which said polyvinyl alcohol solution is applied to provide an amount of polyvinyl alcohol on a dry basis ranging from about 0.3 pounds to about 1 pound per ton of paper on a dry basis.

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