Jan. 28, 1964 J. C. JOHNSON 3,119,730

NON-FLOATING, HIGH ALPHA DISSOLVING PULP SHEET

Filed Aug. 12, 1960 2 Sheets-Sheet 1

FIG. 1.

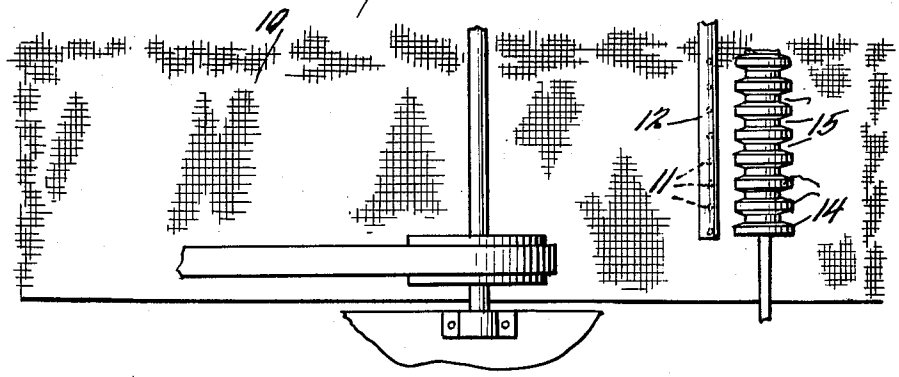


FIG. 2.

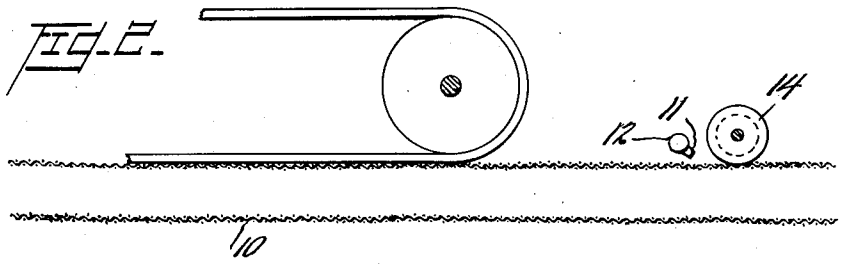
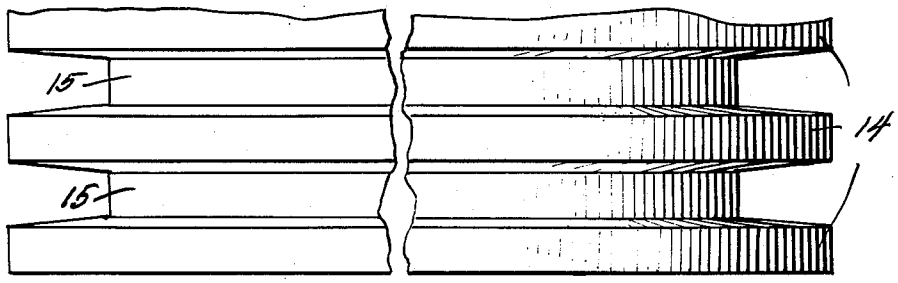


FIG. 3.



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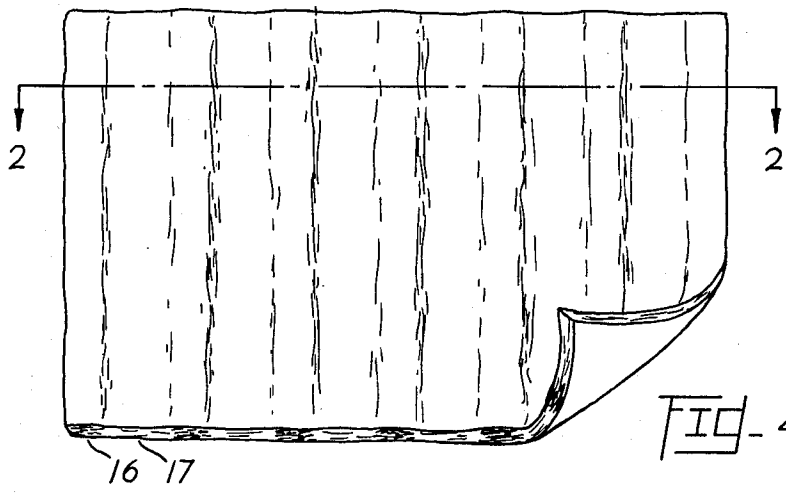


FIG. 4

FIG. 5



FIG. 6

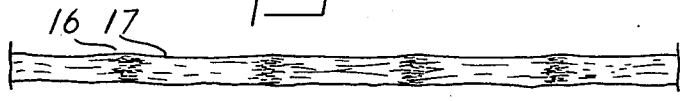
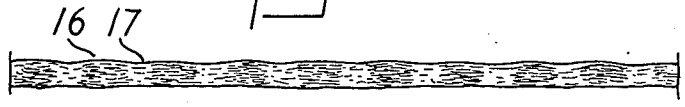


FIG. 7



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NON-FLOATING, HIGH ALPHA DISSOLVING PULP SHEET

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This invention relates to the provision of a new and useful prehydrolyzed chemical wood pulp sheet of pine fibers, which sheet is intended for use in cellulose regeneration processes involving the step of steeping cellulose sheets in aqueous sodium hydroxide solution to produce alkali cellulose. More particularly, this invention relates to the discovery of a novel sheet of prehydrolyzed sulfate pine pulp having an alpha cellulose content in excess of 96% which does not tend to float upwardly, or displace, in the trough of a sheet steeping press when subjected to the action of fresh or used aqueous sodium hydroxide solutions in the widely practiced sheet steeping procedure for the production of alkali cellulose for viscose rayon and the like.

Specifically the sheet of the present invention can be produced by a particular method of forming refined prehydrolyzed sulfate pine pulp on the Fourdrinier section of a paper machine while maintaining set limits in physical formation with regard to the alpha cellulose content of the formed pulp. The herein disclosed invention solves the serious problem of cellulose sheet flotation, or displacement, in the books of caustic steeping presses which developed when refined chemical pine pulps purified to alpha cellulose contents exceeding about 96% were employed in the sheet steeping process for preparing alkali cellulose.

It is therefore an object of this invention to provide a chemical wood pulp sheet formed from pine cellulose fibers having an alpha cellulose content in excess of 96% which will not float in a sheet steeping process.

It is also an object of this invention to provide a refined chemical wood pulp sheet derived from pine and containing more than 96% alpha cellulose which has outstanding utility in the manufacture of regenerated cellulose products in processes including caustic sheet steeping as an essential step.

It is a further object of this invention to obtain beneficial results in the processing of high-alpha prehydrolyzed sulfate pine pulp sheets by providing a sheet of such pulp formed while maintaining close control of its physical characteristics.

It is a still further object of this invention to provide sheets of prehydrolyzed sulfate chemical wood pulp derived from pine and having an alpha cellulose content in excess of about 96% which when collected into books and placed in a caustic steeping press will not require artificial means or additional labor to maintain them in position during the introduction of the steeping caustic.

Moreover, it is an object of this invention to eliminate the so-called "brown-spots" which normally appear on pulp sheets in the caustic steeping press in conjunction with providing the hereinbefore mentioned non-floating sheets of prehydrolyzed sulfate chemical pine pulp having a high content of alpha cellulose.

Further objects and advantageous features will appear from the following detailed description of the high-alpha prehydrolyzed sulfate pine pulp sheet of this invention, taken in connection with the accompanying drawings in which:

FIGURE 1 is a fragmentary plan view of the Fourdrinier section of a pulp drying machine;

FIGURE 2 is a side elevation of the structure shown in FIGURE 1;

FIGURE 3 is an enlarged partial front elevation of the forming roll shown in FIGURE 1;

FIGURE 4 is a plan view of a prehydrolyzed sulfate pine pulp sheet according to the preferred embodiment of the invention;

FIGURE 5 is a transverse section of the pulp sheet shown in FIGURE 4 taken along line 2—2; and

FIGURES 6 and 7 are transverse sections of additional prehydrolyzed sulfate pine pulp sheets according to the practice of the invention.

Refined chemical wood pulps have gradually increased in alpha content from about 85% to 98% as the digestion and bleaching treatments for the conversion of wood chips into refined chemical wood pulps have become increasingly sophisticated in the number of steps, treatment control, and chemical knowledge applied to the removal of color bodies, lignins, hemicelluloses, and other extraneous material. The general thought of manufacturers utilizing refined chemical wood pulps has been that their suppliers should strive for purity, i.e., high alpha cellulose content. The attainment of this goal while meeting the desires of these manufacturers for high yields, finished product stability, etc., has not always had equally beneficial side effects in processing. It is the elimination of several of these undesirable side effects which is the principal concern of the present invention.

As pulping processes were developed to the extent that pine pulps containing 96% alpha cellulose, or above, resulted, manufacturers of regenerated cellulose products employing the sheet steeping procedure for converting cellulose sheets to alkali cellulose began to experience floating problems in their caustic steeping presses.

In the sheet steeping procedure for converting cellulose to alkali cellulose, a caustic steeping press consisting of a U-shaped trough having closed ends and a movable ram at the opposite end connected to a source of power for extension of the ram is employed. Sheets of chemical pulp of approximately 18" x 20", having their greater dimension in the direction of travel on the pulp drying machine, are gathered into books of 14–20 sheets and placed vertically in the trough of the steeping press. Separating such books for convenience in handling are perforated divider plates hanging down into the trough and supported at the top by the trough sides.

When the steeping press has been loaded with books of pulp sheets, an aqueous sodium hydroxide solution containing approximately 18.5% sodium hydroxide is fed into the trough through an inlet at the bottom. This solution is fed into the trough at approximately the same rate at which the solution rises in the pulp sheets by capillary action until the top edges of the sheets are approximately one-half inch below the solution surface. This step is known as the "run-on." If the pulp books rise, rotate, or otherwise disarrange themselves during the "run-on," the problem is known as "floating" and the result is a non-uniform alkali cellulose less suitable for further processing steps. The manufacturers of alkali cellulose and subsequent products have used bars or weights along the top of the troughs to combat floating, and have expended labor to tend the steeping presses and straighten up the sheets as they become saturated with the sodium hydroxide solution. This latter operation is known descriptively as "dressing" the books. After the books have steeped for a sufficiently lengthy period to effect their conversion into alkali cellulose, the sodium hydroxide solution is drained from the steeping press, and the ram is advanced so that the excess solution is pressed from the sheets until the wet weight of the alkali cellulose is in the range of about 2.6 to about 3.1 times the weight of the original cellulose. The ratio of the weight of the wet alkali cellulose to the weight of the original cellulose is generally termed the press factor or the press weight

ratio. From this description it is easily understood that imperfect penetration of the sheets by the sodium hydroxide solution or imperfect pressing of the sheets caused by their disarrangement in the press will result in a non-uniform alkali cellulose for use in subsequent processing steps such as xanthation. Such non-uniform alkali cellulose leads to poor viscose filtration, loss in yield, and low-grade final products. Specific faults developed in the steeping step due to imperfect penetration or pressing are "brown-spots" on the pressed sheets which are well known in the viscose industry, and "wet edges" due to non-uniform ram pressure on the edges of any displaced sheets during pressing.

It has been discovered that a particular method of forming the high-alpha pulp sheets on the Fourdrinier section of a pulp drying machine coupled with the high density pressing normally applied to a dissolving pulp sheet will eliminate the aforementioned difficulties which are present in highly refined chemical pine pulp having an alpha content in excess of 96% alpha cellulose.

After the forming step has been controlled to produce the sheet of the present invention the action of the normal smoothing, drying and pressing rolls of the pulp drying machine results in a substantially flat finished sheet having machine direction stripes of high and low basis weight in a selected width pattern dependent on the groove and land arrangement of the forming roll used on the Fourdrinier wire.

Since the magnitude of the swelling action of steeping caustic on a pulp sheet is in direct proportion to its ream weight, the presence of stripes of high and low basis weight leads to a ridge and valley configuration in the steeped sheet due to the swelling action of the aqueous sodium hydroxide solution employed.

While the practice of watermarking or water-forming is old in the art, the presence of watermarking will not insure non-floating in pine pulps having an alpha content in excess of 96% and it only is when the stripe configuration and control of ream weight ratio of the present invention is applied that the beneficial result is attained.

The non-floating sheets of the present invention are formed from prehydrolyzed sulfate chemical wood pulp prepared from pine fibers having an alpha celluose content in excess of about 96%. Below this alpha cellulose content, the floating problem does not appear or can be controlled by increasing the sheet density.

The present non-floating sheet is therefore characterized by possessing an alpha cellulose content in excess of about 96% alpha cellulose and being composed of longer pine fibers. The floating problem is prevented by forming the sheet on the Fourdrinier wire prior to the suction boxes in such a manner that alternating machine-direction stripes of higher and lower ream weight result. The effective stripe pattern is found to range from a 1/8 inch higher ream weight stripe in combination with a 1 inch lower ream weight stripe combination to a 3/8 inch higher ream weight stripe in combination to a 3/16 inch lower ream weight stripe. It will be understood that the stripe pattern is one of successive higher and lower ream weight machine-direction stripes across the width or deckle of the formed pulp sheet. The formation of higher and lower ream weight stripes in the manner described will not of itself insure the non-floating characteristic. Therefore, it is an essential part of the practice of the present invention that the ratio of the higher and lower ream weight stripes in the pulp sheet must be controlled to insure non-floating. The necessary control is accomplished by reforming the sheet on the Fourdrinier wire after preliminary sheet formation. Furthermore, it has been found that to insure non-floating the ratio must be increased from a minimum of about 1.1 at an alpha-cellulose content of about 96% to a minimum of about 1.5 at an alpha cellulose content of about 97%. Furthermore, in sheets with alpha contents greater than 99%, it is necessary to increase the ratio of stripe ream weights to about 1.8.

The ratio of the stripe ream weights is obtained by dividing the weight of a given area of the higher ream weight stripes by the weight of an equal area of the lower ream weight stripes.

The desired properties of a cellulose sheet for use in a caustic steeping press in regard to stiffness, handling and ream weight taken together with the heretofore mentioned necessity of maintaining higher to lower ream weight ratios of between 1.1 and 1.8 depending on the alpha cellulose content of the pulp sheet require average sheet ream weights of about 105 to about 315 pounds (based on the weight of 500 sheets—19" x 24").

When the ream weight ratio of 1.5 necessary for a pulp sheet having an alpha cellulose content of about 97% is maintained with a forming roll having the configuration described hereinbelow, the practical limitations above result in about an 84 pound ream weight for the lower ream weight stripe and about a 126 pound ream weight for the higher ream weight stripes at the minimum average ream weight limit. Also with about a 97% alpha sheet, at the maximum average ream weight limit the lower ream weight stripe will have a ream weight of about 252 pounds while the higher ream weight stripe will have about a 378 pound ream weight. As will be evident to those skilled in the art, the limitations are made partly necessary by the practical necessity of maintaining a minimal amount of pulp in the low ream weight stripes for sheet coherence.

The stripes can be formed on the sheet by running prehydrolyzed sulfate chemical pine pulp on a pulp-drying machine Fourdrinier wire of conventional type, such as is diagrammatically illustrated in the accompanying drawing in which the wire is indicated at **10**, the pulp being supplied to the wire from the usual headbox, not shown. Immediately above the wire and extending transversely thereof is a shower pipe **12** which may be perforated at intervals corresponding to the spacing of the stripes so as to supply an excess of water immediately below the perforations, whereby the pulp is made adequately fluid for fiber displacement. If desired the perforations in pipe **12** may discharge through nozzles **11** to jet the water against the pulp web previously formed on the Fourdrinier wire. Immediately beyond spray pipe **12** is a forming roller mounted for vertical adjustment, and provided with special annular lands **14** and grooves **15** intermediate the lands, each land being substantially in line with a perforation in spray pipe **12**. As the sheet passes under the forming roller, the fibers are displaced by the lands to form stripes of lower ream weight **17**, thus providing stripes of higher ream weight **16** therebetween.

Thereafter the sheet moves over conventional suction boxes followed by subsequent normal apparatus and thence into the dryer section of the usual pulp-drying machine. Located centrally in the drier section are high density press rolls which compress the sheet, the latter becoming substantially flat at this point. The nip pressure of these high density rolls is adjusted to between 400 and 1000 pounds per linear inch of sheet width with the applied pressure being preferably about 800 pounds per linear inch of sheet width.

FIGURES 4 and 5 illustrate the preferred prehydrolyzed sulfate pine pulp sheet having 5/16 inch wide higher ream weight stripes **16** and 1/2 inch wide lower ream weight srtipes **17**. FIGURE 6 is a transverse section of a prehydrolyzed sulfate pine pulp sheet having 1/8 inch wide higher ream weight stripes **16** and 1 inch wide lower ream weight stripes **17**. FIGURE 7 is a transverse section of another embodiment of the present invention having 3/8 inch wide higher ream weight stripes **16** and 3/16 inch wide lower ream weight stripes **17**.

It will be appreciated that the apparatus illustrated in the drawing and described briefly hereinbefore is well-

known in the art and may be varied considerably in the practice of invention. For instance the water content or fluidity of the pulp may be adjusted without the water jets by controlling the consistency of the pulp slurry in the headbox of the pulp-drying machine so that sufficient water is present in the pulp at the forming roll to permit fiber displacement by the annular lands thereof. This control may be accomplished by raising or lowering the setting of the consistency regulator normally regulating the consistency of the pulp slurry in the headbox.

Although a steel roller was tried, it has been found that a hard rubber cover on a roller designed to prevent deflection is preferable. A hard rubber covered roller having a diameter of 18 inches with 3/8 inch wide annular lands, or raised rings, tapering to 1/2 inch at their root and 1/2 inch grooves (at the periphery) gives effective results. The depth of the grooves is 3/4 inch. The height of the raised rings above the Fourdrinier wire is adjusted to result in a 1.1 stripe ream weight ratio when running wood pulp having an alpha content of 96% and is adjusted closer to the wire to result in a stripe weight ratio of 1.8 as the alpha-cellulose increases to 99%. As an alternative method to the above, the fluidity of the pulp sheet may be controlled by adding water to the sheet just prior to the forming roller by means of a transversely mounted shower pipe.

Operating in the preferred manner with prehydrolyzed wood pulp having an alpha content of about 97.4%, the finished pressed sheet has an average ream weight of about 210 pounds with 5/16 inch wide high ream weight stripes alternating with 1/2 inch wide low ream weight stripes. The clearance between the following roller and the wire is adjusted to result in a ream weight ratio of 1.5 between the high and low stripes.

Example I

Prehydrolyzed sulfate chemical pine pulp slurry (pulp and water) having an alpha cellulose content of 97.4% was run onto the Fourdrinier wire of a pulp drying machine. Water jets from a shower pipe mounted 4 inches above and transversely to the direction of the moving pulp web were directed downwardly to impinge on the moving web surface. The water jets were spaced at intervals of approximately 7/8" apart although it will be seen in Example III that their placement is secondary to their function of supplying sufficient water to the web to permit displacement of the relatively long pine fibers by the annular lands of the forming roller. A transversely mounted forming roller having 3/8 inch circumferential ridges (tapering to 1/2 inch at their roots) and 1/2 inch grooves in its surface was placed in a position subsequent to the shower pipe in the direction of web travel. The forming roll was mounted so that its height above the Fourdrinier wire was adjustable, and the height was adjusted so that the basis weight of the high basis weight stripes formed in the web were 1.5 times the basis weight of the low basis weight stripes formed by the action of the water and forming roller prior to the suction box, said high basis weight stripes having a width of about 5/16 inch and said low basis weight stripes having a width of about 1/2 inch.

The relative basis weights of the high and low basis weight stripes were determined by punching six 1/4 inch diameter circles from the low basis weight stripes and weighing them collectively on an analytical balance, repeating the procedure for the high basis weight stripes, and finally dividing the weight obtained for the high basis weight stripes by that obtained for the low basis weight stripes.

The thus formed pulp web was run thru the normal high density press rolls located centrally in the dryer section using a nip pressure of 800 pounds per linear inch whereby a substantially smooth final pulp sheet resulted. The average ream weight of this sheet (basis 500 sheets—19" x 24") was found to be 210 pounds.

The pulp web was wound into a parent roll at the dry end of the machine. This parent roll was later cut into 19 x 24 inch sheets by a normal slitter-cutter layboy installation. The sheets were cut so that the previously formed stripes ran in the 24 inch direction.

Fourteen of the so formed sheets were taken as a "book" in the sheet steeping step of viscose rayon manufacture and were placed in an upright position in the trough of a sheet steeping press with the stripes in a vertical position. Another book of pulp sheets was prepared in the manner of this example from identical pulp and differing only in that the pulp sheets of this book had a low to high basis weight ratio of 1.4 instead of 1.5 were placed in an adjacent partition of the steeping press.

When the 18.5% aqueous sodium hydroxide used for steeping was introduced into the bottom of the steeping press the book having a ratio of 1.5 between the basis weights of its high and low basis weight stripes remained in place and absorbed the caustic evenly while the book having a ratio of 1.4 floated in the steeping trough.

Example II

In a test conducted in the same manner as that of Example I above, differing only in that prehydrolyzed sulfate chemical pine pulp having an alpha content of 96.5% was used to prepare the pulp sheets instead of pulp having an alpha content of 97.4% alpha cellulose, it was found that a ratio of 1.1 between the high and low basis weight stripes was sufficient to preclude floating while sheets having no stripes formed (i.e., a high to low basis weight ratio of 1.0) did float.

Example III

Again in a test conducted in the same manner as that of Example I, but wherein the fluidity of the entire sheet was increased by supplying additional water to the pulp slurry in the headbox to permit effective displacement of the fibers by the forming roll, pulp sheets yielding comparable results were obtained.

Example IV

Pulp sheets formed of prehydrolyzed sulfate chemical pine pulp having an alpha cellulose content of 99% formed in the manner of Example I will not float in steeping caustic at a high to low basis weight stripe ratio of 1.8, while a basis weight ratio of 1.7 at this alpha content will result in floating.

While the specific ranges of stripe widths described herein are considered to reasonably define the practical limits of successful operation, it is possible that some further variations will exist for particular combinations of pulp types and pulp-drying machine conditions. Subject to the basic requirements that the pulp web shall run satisfactorily on the pulp-drying machine and that the resulting sheet be non-floating, a variety of particular stripe configurations will suggest themselves to those skilled in the art.

Again, those persons skilled in the manufacture and utilization of chemical pulp will readily understand that although the present invention has been described in terms of prehydrolyzed sulfate pine pulp that the sheet formation described herein will be applicable to any pulp sheet composed of long fibered coniferous pulp having an alpha cellulose content in excess of about 96% and subject to the problem of floating.

Having thus disclosed and described the invention there is claimed:

1. A prehydrolyzed sulfate chemical pine pulp sheet having substantially flat surfaces for use in the sheet steeping procedure for the production of alkali cellulose, said sheet having an alpha cellulose content in excess of about 96% and an average ream weight of from about 105 to about 315 pounds on the basis of the bone dry weight of 500 sheets measuring 19" x 24", said sheet having parallel and adjacent stripes of lower and higher ream weight running in the machine direction such that the ratio of

the basis weight of the higher ream weight stripes to the basis weight of the lower ream weight stripes is at least about 1.1 in a sheet containing about 96% alpha cellulose and at least about 1.8 in a sheet containing about 99% alpha cellulose and has corresponding intermediate minimum values for sheets of intermediate alpha cellulose content, said parallel stripes being from about ⅛" of width in the higher ream weight stripes and about 1 inch of width in the lower ream weight stripes to about ⅜ inch of width in the higher ream weight stripes and about 3/16 inch of width in the lower ream weight stripes.

2. A prehydrolyzed sulfate chemical pine pulp sheet having substantially flat surfaces for use in the sheet steeping procedure for the production of alkali cellulose, said sheet having an alpha cellulose content of about 97.4% and an average ream weight of about 210 pounds on the basis of the oven dry weight of 500 sheets measuring 19" x 24", said sheet having parallel and adjacent higher and lower ream weight stripes running in the machine direction such that the ratio of the basis weight of the higher ream weight stripes to the basis weight of the lower ream weight stripes is at least 1.5, said higher ream weight stripes having a width of about 5/16" and said lower ream weight stripes having a width of about ½".

3. A prehydrolyzed sulfate chemical pine pulp sheet

having substantially flat surfaces for use in the sheet steeping procedure for the production of alkali cellulose, said sheet having an alpha cellulose content of about 96% and an average ream weight of about 210 pounds on the basis of the oven dry weight of 500 sheets measuring 19" x 24", said sheet having parallel and adjacent higher and lower ream weight stripes running in the machine direction such that the ratio of the basis weight of the higher ream weight stripes to the basis weight of the lower ream weight stripes is at least 1.1, said higher ream weight stripes having a width of about 5/16" and said lower ream weight stripes having a width of about ½".

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