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Egan

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[54] **WOVEN PAPERMAKING DRAINAGE FABRIC HAVING FOUR SHED WEAVE PATTERN AND WEFT THREADS OF ALTERNATING DIAMETER**

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[52] U.S. Cl. .... **139/420 R**, 139/425 A, 162/348, 162/DIG. 1, 245/2, 245/8

[51] Int. Cl. **D21f 1/10**

[58] Field of Search .... 162/348, DIG. 1; 139/383 A, 425 A, 420 R, 425 A; 245/2, 8

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[57] **ABSTRACT**

A papermaking fabric woven from synthetic monofilaments is shown in which the warp threads pass under one and then over three weft threads in a repeated pattern, and the weft threads alternate in diameter to develop a fabric wear surface that is uneven with the average level of the smaller diameter weft threads being receded into the fabric to a greater degree than for the larger weft threads.

7 Claims, 4 Drawing Figures

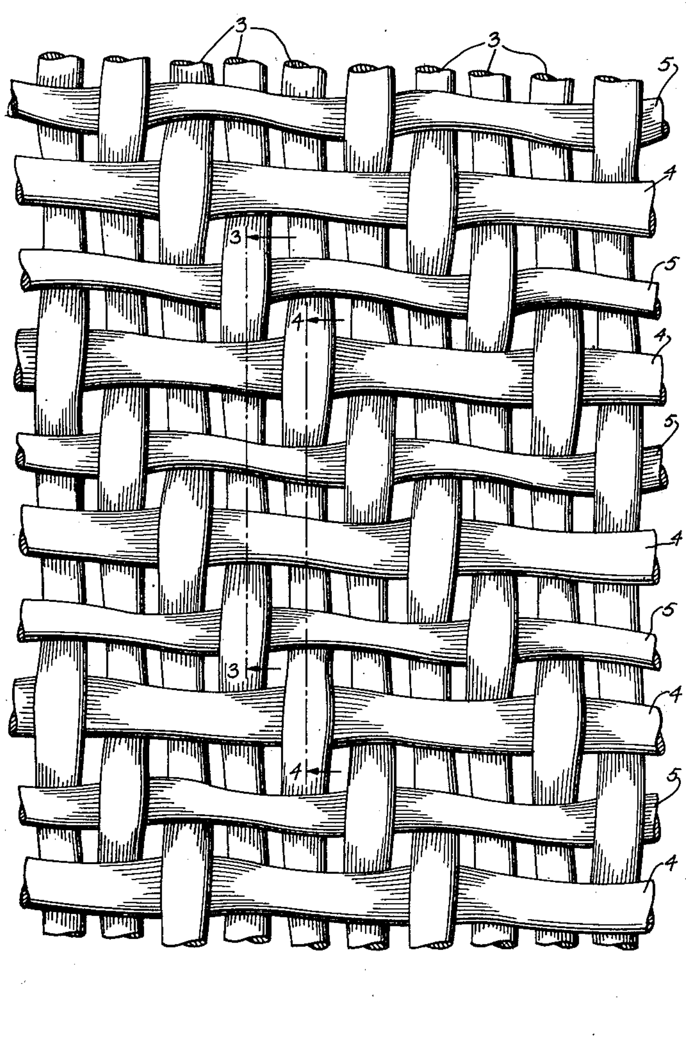


Fig. 1

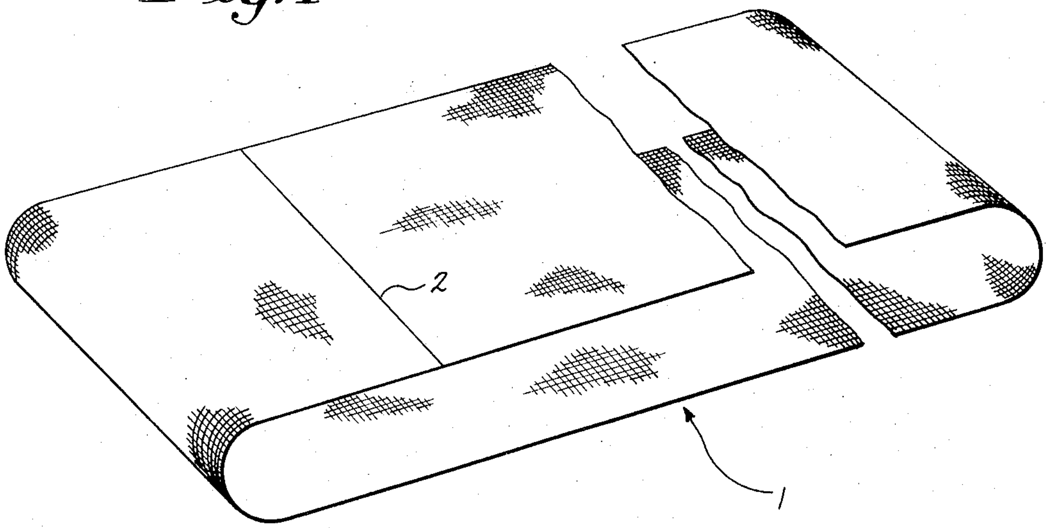


Fig. 3

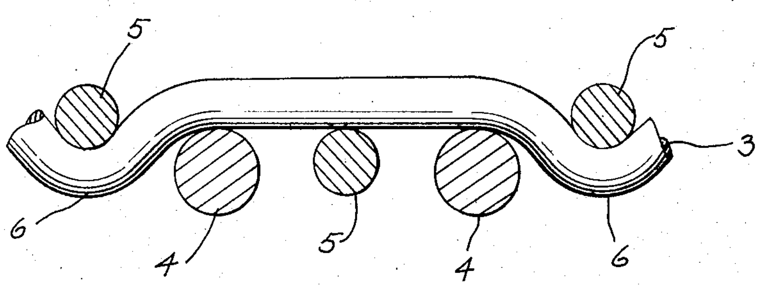


Fig. 4

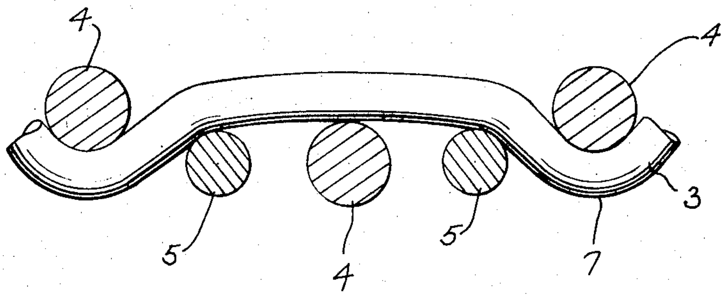
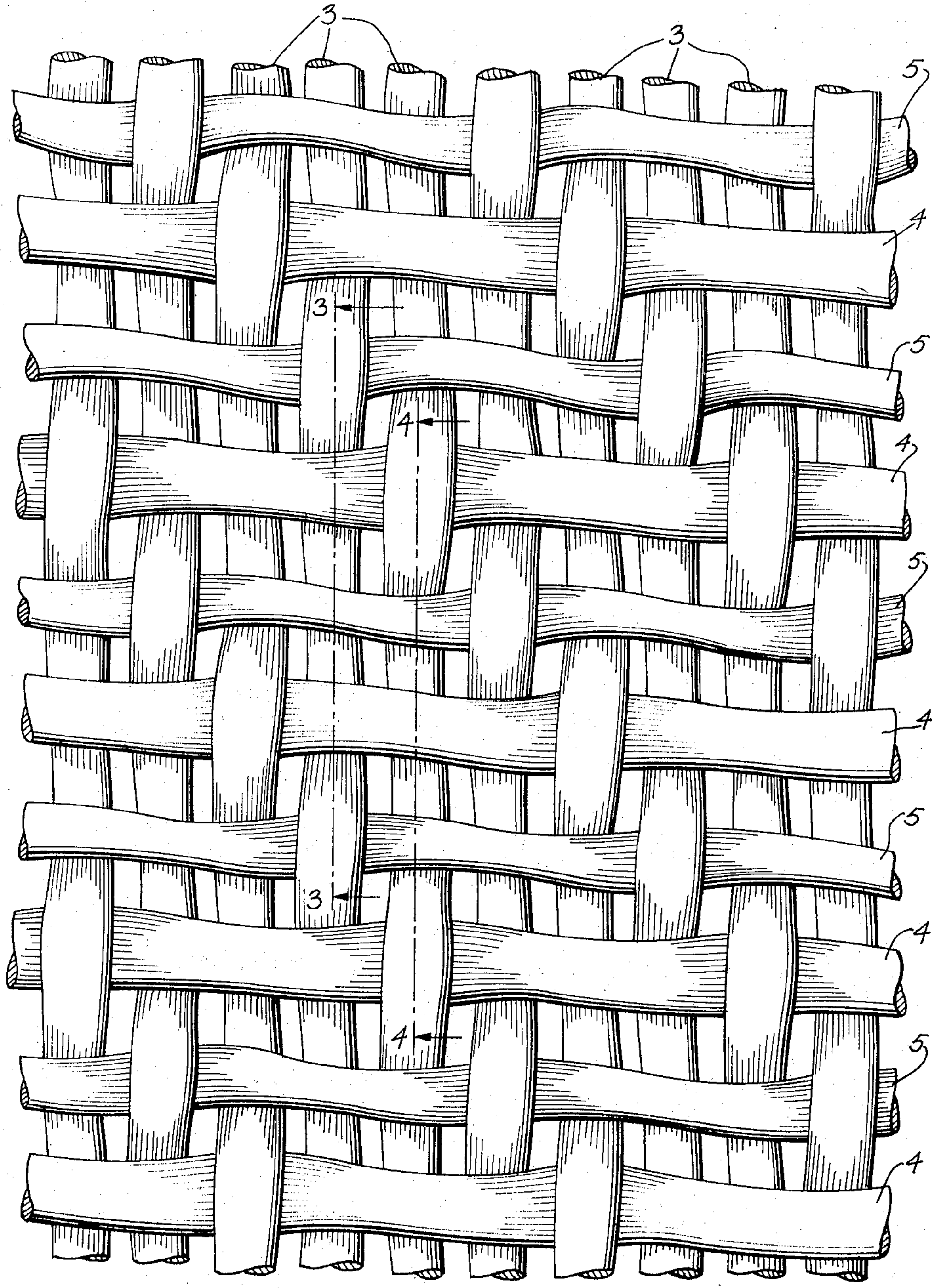


Fig. 2



WOVEN PAPERMAKING DRAINAGE FABRIC HAVING FOUR SHED WEAVE PATTERN AND WEFT THREADS OF ALTERNATING DIAMETER

BACKGROUND OF THE INVENTION

This invention relates to the field of papermaking fabrics, particularly as used on Fourdrinier machines.

In the manufacture of paper on a Fourdrinier machine a slurry of paper pulp is laid down on a large, moving belt in the form of a woven open mesh fabric. Water is drained from the pulp through the fabric to form the pulp fibers into an initial paper web, which web is then transferred from the Fourdrinier machine to the dryer section of the papermaking apparatus.

Fourdrinier fabrics have been woven in a variety of weave patterns and from a large selection of materials. For many years they were woven from metal wire with soft brass for the recessed weft threads and bronzes for the warp threads which were exposed at their knuckles on the wear side to take the primary wear. Other metals including stainless steel have been employed, and both single and multiple strands as well as hollow wires have been woven into Fourdrinier fabrics. Weave patterns have consisted of plane weaves, semi-twill weaves, and a variety of four shed weaves. In recent years synthetic materials have been introduced into the art, and at times they have been intermixed with metal threads. Also, there has been some use of synthetic coated metal wires.

Synthetic threads can be selected from a variety of materials. Some of the earlier work used nylon for its abrasive resistant characteristics, but there has been a shift to polyesters which are nearly non-water absorbent and generally inert to paper pulp slurries. Both monofilament and multi-strand synthetic threads have been used. One of the problems with synthetic materials is that they do not take a permanent set, as do metal threads, when crimped in the weaving process, and a variety of treating techniques have been developed to dimensionally stabilize the synthetic fabrics after weaving.

A Fourdrinier fabric must satisfy a number of requirements in order to be suitable for papermaking. It must present a smooth surface on its upper or papermaking side, in spite of the open mesh characteristic, so that the resulting paper web will not carry wire marking from the fabric. It must have proper water drainage rates and retain the finer pulp fibers on the surface, rather than to lose them in the draining water. It must function as a web forming medium in which paper fibers become intertwined with an adequate percentage in the cross machine direction. The under, or wear side should not groove suction boxes, machine rolls or foils. A fabric must also have adequate tensile strength to be drawn around and over the machine rolls at high speeds, and it should be dimensionally stable, without excessive stretch. Further, a fabric should lie smooth and not buckle or warp in any of its surface regions. The fabric should be woven in such a manner that adequate seams with requisite life and strength can be used to join the fabric ends into an endless belt.

A particular objective is to provide a fabric that will have a long life, for the down time involved in installing and removing fabrics on a Fourdrinier machine is very costly. Metal fabrics had lives measured in days, and synthetic materials have lasted, in contrast, for weeks and months. Hence, there has been a shift in the industry from the metal to the synthetic materials. Longer life has been the result of enhanced abrasion resistance and less wear from passing over suction boxes, machine rolls and foils. Also, the chemical inertness and resistance to corrosion has been a factor favoring synthetic materials.

In meeting the foregoing variety of requirements, each fabric must also be compatible with, and tailored for the particular papermaking machine on which it is to be used. Hence, results of weaves, patterns and materials successful in one installation may not necessarily be satisfactory in another application. Also to be considered is the fineness of the fabric mesh. Some weaves are as coarse as less than 10 warp threads to the inch, whereas other weaves have several hundred warp threads to the inch. Usually the number of weft threads per inch is somewhat less, but there are notable exceptions to this generalization.

Into this extensive background of weaving techniques and practices, the present invention introduces an uneven surface on the wear side of a fabric for the principal purpose of further improving fabric life.

SUMMARY OF THE INVENTION

The invention resides in a Fourdrinier fabric having weft threads of varying diameter with points along the smaller diameter wefts being at a different level in the fabric than the corresponding points of the larger diameter wefts to develop an uneven surface.

It is usual to have all the warp threads of one diameter and all the weft threads of another diameter. By introducing weft threads of alternating diameter the wear surface is made more uneven than in usual weaves. It may be an anomaly to speak of a fabric surface, when it is an open mesh and comprised of threads woven into knuckles at cross over points, and with the threads following a somewhat sinuous configuration which does not define a plane at all. Nonetheless, the term surface is used herein to denote the general contour as seen from one side or the other of the fabric, and the points along a thread are referred to as being at levels within the fabric meaning at a level, or height, within the maximum thickness of the fabric as measured from the outermost thread knuckle surfaces that define the outermost planes of the fabric.

It is not in of itself novel to use weft threads of varying diameter. In U.S. Pat. No. 3,216,893 this is done, but metal wefts alternate with plastic wefts in a plain weave, i.e., one over-one under, and the plastic weft are the larger in diameter in order to have all warp knuckle crests lie in a single plane on each side of the fabric. The goal there is to have a mono-plane on each fabric side that is composed of warp knuckles alone. That is a quite different objective from that of the present invention. Reinforcing strands of smaller diameter have been laid in a nonwoven relation alongside the warp threads of the selvedge area in U.S. Pat. No. 3,523,867, and in U.S. Pat. No. 1,616,222 a Fourdrinier fabric has larger than normal warp and weft threads at spaced intervals along the fabric to change drainage characteristics for developing water marks in the resulting paper. Neither of these practices is similar to the present invention.

In the invention the weft preferably alternate in diameter so that adjacent threads on one side of the fabric lie at different average levels in the fabric. This unevenness of the thread levels within the fabric occurs with the minute spacing of adjacent threads over the entire fabric surface. When this non-uniform surface is used as the wear surface increased fabric life has resulted. The reason is not fully understood, but it may be surmised that the water flow characteristics through the fabric, particularly the lower part of the fabric that rides over suction boxes, machine rolls and foils has been modified. Water may more readily flow along the fabric wear surface and form a film which lubricates the individual threads to reduce abrasive wear. Or, it may be that the provision of some larger weft threads introduces larger wear surface areas which prolong fabric life. Since the exact nature of the phenomena involved is not known, these explanations are not to be construed as any limitation in the definition of the invention.

Principal objects of the invention are to provide a Fourdrinier fabric that is relatively non-uniform on its wear surface, and to achieve better wear and life characteristics.

The foregoing and other objects and advantages of the invention will appear from the following description. In the description reference is made to the accompanying drawings which form a part hereof, and in which there is shown by way of illustration and not of limitation a preferred embodiment of the invention. Such embodiment does not represent the full scope of the invention, but rather the invention may be employed in many different embodiments, and reference is made to the claims herein for interpreting the breadth of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a view in perspective of a Fourdrinier fabric embodying the invention,

FIG. 2 is a view of the wear side on an enlarged scale of a portion of the fabric of FIG. 1,

FIG. 3 is a view in section taken through the plane 3—3 indicated in FIG. 2, and

FIG. 4 is a view in section taken through the plane 4—4 indicated in FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 shows a Fourdrinier fabric 1 formed by joining together the opposite ends of a woven length of the fabric along a seam 2. The finished Fourdrinier fabric may have a width of up to 30 feet or more, and the length along the loop of fabric may be as much as 180 feet. The dimensions are dependent upon the particular papermaking machine for which the fabric is woven, and those given here are for illustrative purposes only. The upper side of the top half of the fabric 1, as viewed in FIG. 1, is the papermaking side upon which a slurry of pulp fibers is deposited at one end. The inner side of the fabric 1 is the wear side and travels over and around machine rolls and suction boxes, and in more modern machines foils in place of the small bed rolls that were previously used. The fabric 1 is moved along at a substantial speed and water drains through it to develop the fibers into an initial web. By controlling the drainage and shaking the fabric in a cross machine direction the fibers are oriented into random directions with a substantial number becoming aligned in the cross machine direction, to thereby form the desired web which will ultimately have good strength in all directions. By judicious positioning of the rolls, foils and suction boxes, the rate of water removal is controlled to facilitate this formation of a web.

FIG. 2 shows a portion of the wear surface of the fabric 1 on an enlarged scale, with the warp threads 3 running from the top to bottom of the figure. When the fabric 1 is made into a closed loop, as shown in FIG. 1, the warp threads 3 will extend around the loop, which is the machine direction, i.e. the direction in which the fabric 1 is moved over the rolls and other parts of the Fourdrinier machine.

The weft threads shown in FIG. 2 alternate in diameter between a relatively large weft 4 and a smaller weft 5. The warp threads 3, on the other hand, are of a uniform diameter throughout the fabric 1. The warp threads 3 and weft threads 4, 5 are woven in a four shed weave of a 1–2–3–4 pattern. Thus, for any group of four successive warp threads 3 the first will pass beneath some selected weft, the second will pass beneath the next successive weft, the third will pass beneath the next successive weft, and the fourth will pass beneath the next successive weft. This pattern develops a twill like effect. Four shed weaves are also made in a satin pattern in which the warp threads are alternated in the sequence 1–3–2–4, and in full twill weave in which each warp thread passes over two and then under two weft threads, with successive warps being staggered by a single weft thread.

Referring now to FIG. 3, there is shown a section along a warp thread 3 which passes over two large weft threads 4 and a small weft thread 5, and then under a single small weft thread 5 in a repeated pattern. FIG. 4 shows a section along an adjacent warp thread 3 that passes over a pair of small weft threads 5 and a single large weft thread 4, and then beneath a large weft thread 4 in a repeated pattern. In both FIGS. 3 and 4 the papermaking side of the fabric 1 is at the top and the wear side is at the bottom.

For the particular weave from which FIGS. 2–4 were taken the mesh count was 79 warp threads per inch and 56 weft threads per inch. The warp diameter was .20 mm, which is a typical warp diameter for normal fabric of this mesh count. The large diameter weft threads 4 had a diameter of .25 mm and the small diameter weft threads 5 had a diameter of .20 mm. These weft thread diameters compare with .22 mm which would be typical for this particular mesh count of 79 warp threads per inch and 56 weft threads per inch. The large diameter wefts are increased over the normal diameter approximately the same amount as the smaller wefts are decreased in diameter from a normal value. Thus, the silhouette open area of the embodiment being described is similar to that of ordinary fabrics of the same mesh count. Tests of resistance to water drainage indicate that fabrics of the invention should have similar bulk drainage rates as usual fabrics of like mesh, and thus the novel introduction of alternating weft diameter can be worked into Fourdrinier fabrics without material change in other weave parameters.

The warp threads 3 and weft threads 4 and 5 of the fabric of FIGS. 1–4 are preferably of polyester material. As indicated hereinabove, other synthetic materials are used for fabrics of this nature, and nylon, acrylics and copolymers are examples. Also, metal threads, coated metal threads and combinations of these various materials may be feasible for implementing the invention, so long as the uneven characteristic is developed for the fabric surface.

FIGS. 3 and 4 are schematic, for some physical deformation of the threads occurs under the high stresses of weaving, particularly in the vicinities of the crimps and knuckle formations, and these deformations are not shown. These figures do indicate, however, that points along a large diameter weft thread 4 are at a different level than corresponding points along a small diameter weft thread 5. Further, the warp knuckles on the bottom, or wear side, which pass under a small weft thread 5 are at a different level than the warp knuckles 7 that pass under a large weft thread 4. Measurements have indicated that on the wear side of the fabric 1 some part of the knuckles of the large weft threads 4 form the lowermost points of the wear surface. They thus define the outer fabric surface, and the limit of fabric thickness. Moving inward of the fabric 1, or upward in FIGS. 3 and 4, the next thread surface encountered is some part of the knuckles of the small diameter weft threads 5. The next higher thread surface recessed into the fabric 1 are the warp knuckles 7 that pass under large wefts 4. And recessed still further into the fabric 1 are the warp knuckles 6 which pass under the small diameter weft threads 5. The relative levels in the fabric may vary from the results of the foregoing measurements, but as a result of the alternating weft thread diameters the wear surface of the fabric 1, as defined by the individual thread levels in the fabric, is relatively uneven or non-uniform.

A predominant amount of wear will be taken by the large diameter weft threads 4 which have exposed long knuckles on the wear side. A smaller amount of wear will be taken by the small diameter weft threads 5, for they are recessed and also present a smaller surface area. The warp threads 3 will take wear at a later stage of fabric life. This shifting of the wear in a large proportion to some of the weft threads may account for the long life of fabrics of the invention. Another factor may be that the uneven characteristic of the wear surface reduces the suction effect on the fabric 1 as it rides over suction boxes and other machine parts, so that the pressure of the fabric on box surfaces, and the like, is reduced. As a result abrasive wear is reduced and fabric life increases. It also may be theorized that the water flow within the lower regions of the fabric 1 may be altered by the unevenness on the wear side such that the bottom surfaces of the threads are washed or retain a liquid film on their surface as they ride across a suction box and other machine parts. There may be a resulting improved lubrication that increases fabric life. In any event, the invention enhances fabric performance.

By elevating the warp knuckle crests 6 and 7 into the fabric the resulting weave reduces the crimp in the warp knuckles. The resulting shallower warp knuckles will reduce the tendency of the warp threads 3 to stretch under tension. Improved dimensional stability is thereby imparted to the fabric 1. The warp knuckles, however, remain sufficiently deep in curvature to adequately lock with the weft threads 4, 5 so that an overly sleazy fabric is not developed.

The described embodiment introduces an uneven surface characteristic into a Fourdrinier fabric by the use of alternating weft thread diameters. In the practice of the invention it has been usual to reduce the diameter of the smaller wefts from the weft diameter of a normal weave, and to increase the diameter of the larger weft above that of normal weaves. While silhouette open areas are not materially affected, and drainage appears to remain the same as comparable prior fabrics, there is some increase in the total bulk of the weft thread material. This may account to some extent for enhanced wear characteristics of the fabric.

The difference in the diameters of the large and the small weft threads should be at least 10 percent of the smaller of the two diameters. This difference can extend upward to 50 percent, although for different installations this upper limit may undoubtedly vary. For these ratios it is assumed that warp diameters will be held equal throughout the fabric. This need not, however, be a limitation in the practice of the invention, nor should the specific weave be a limiting factor if the non-uniform, or uneven surface characteristic is developed.

I claim:

1. In a Fourdrinier papermaking drainage fabric of interwoven warp and weft threads, the combination of:

a four shed weave pattern with both the warp threads and the weft threads passing around one of the other threads on one side of the fabric and then around three of the other threads on the opposite side of the fabric;

the warp threads being of substantially uniform diameter;

the weft threads being of an all synthetic material and alternating in diameter with every second thread being of a diameter larger than the alternate threads therebetween, the difference in weft thread diameters being at least 10 percent of the smaller weft thread diameter; and

crests of warp knuckles on the wear side of the fabric being receded within weft knuckle crests.

2. A papermaking fabric as in claim 1, wherein both the warp and weft threads are of a synthetic monofilament material.

3. A papermaking fabric as in claim 1, wherein the diameter of the warp threads is less than the values of the small and large weft thread diameters.

4. A papermaking fabric as in claim 1, wherein the average surface level of the smaller weft threads is receded into the fabric a greater degree than the average level of the larger weft threads.

5. In a Fourdrinier papermaking fabric of interwoven warp and weft threads that produce an open mesh for water drainage, the combination of:

the warp and weft threads being woven in a repeated four shed pattern and comprised of synthetic material;

adjacent weft threads varying in diameter with every other thread being of larger diameter than the threads therebetween and with the minimum difference in weft thread diameters being at least 10 percent of the smallest weft thread diameter; and

the large diameter weft threads forming the outermost surface of the wear side, smaller diameter weft threads being recessed within this outermost surface, and warp knuckles on the wear side also being recessed within such outermost surface of the wear side.

6. A papermaking fabric as in claim 5, with the warp knuckles on the wear side being recessed further within

the fabric than the knuckles of the smaller diameter weft threads.

7. In a paperforming, drainage fabric of interwoven machine direction threads and threads crosswise thereto, such threads being woven of monofilament, synthetic materials in a four shed weave, the combination of:

said crosswise threads being composed of different diameter threads of relatively large diameter threads alternating with relatively small diameter threads;

the difference in diameter of the relatively large and relatively small crosswise threads being at least 10 percent of the smaller diameter;

said crosswise threads having the long knuckles thereof, that traverse more than one machine direction thread, being exposed on the wear side of the fabric;

the average level of the long knuckles of said relatively small diameter crosswise threads being recessed within the relatively large diameter crosswise threads; and

the knuckles of the machine direction threads being shallower than for the crosswise direction threads, and on the wear side being recessed within the knuckles of the relatively large diameter crosswise threads.

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