(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 553 501 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
28.10.1998 Bulletin 1998/44

(51) Int Cl.[6]: **D21F 1/00**

(21) Application number: **92122165.1**

(22) Date of filing: **15.03.1991**

(54) **Papermakers fabric with flat machine direction yarns**

Papiermachergewebe mit flachen Längsfäden

Toile pour papeterie ayant des fils dans le sens de la longueur de la machine à section droite aplatie

(84) Designated Contracting States:
AT BE CH DE DK ES FR GB GR IT LI LU NL SE

(30) Priority: **06.06.1990 US 534164**
15.08.1990 US 567974
14.02.1991 US 654008

(43) Date of publication of application:
04.08.1993 Bulletin 1993/31

(62) Document number(s) of the earlier application(s) in accordance with Art. 76 EPC:
91907325.4 / 0 532 510

(73) Proprietor: **V. ASTEN S.C.**
4700 Eupen (BE)

(72) Inventor: **Lee, Henry J.**
No. B2, Summerville, SC 29483 (US)

(74) Representative: **Boydell, John Christopher et al**
Stevens, Hewlett & Perkins
1 Serjeants' Inn
Fleet Street
London EC4Y 1LL (GB)

(56) References cited:
EP-A- 0 144 592
EP-A- 0 211 426
FR-A- 2 407 291
US-A- 4 123 022
US-A- 4 438 789
US-A- 4 865 083

Note: Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

EP 0 553 501 B1

Description

The present invention relates to papermakers fabrics and in particular to fabrics comprised of flat monofilament yarns.

BACKGROUND OF THE INVENTION

Papermaking machines generally are comprised of three sections: forming, pressing, and drying. Papermakers fabrics are employed to transport a continuous paper sheet through the papermaking equipment as the paper is being manufactured. The requirements and desirable characteristics of papermakers fabrics vary in accordance with the particular section of the machine where the respective fabrics are utilized.

With the development of synthetic yarns, shaped monofilament yarns have been employed in the construction of papermakers fabrics. For example, U.S. Patent No. 4,290,209 discloses a fabric woven of flat monofilament warp yarns; U.S. Patent No. 4,755,420 discloses a non-woven construction where the papermakers fabric is comprised of spirals made from flat monofilament yarns.

Numerous weaves are known in the art which are employed to achieve different results. For example, U. S. Patent No. 4,438,788 discloses a dryer fabric having three layers of cross machine direction yarns interwoven with a system of flat monofilament machine direction yarns such that floats are created on both the top and bottom surfaces of the fabric. The floats tend to provide a smooth surface for the fabric.

Permeability is an important criteria in the design of papermakers fabrics. In particular, with respect to fabrics made for running at high speeds on modern drying equipment, it is desirable to provide dryer fabrics with relatively low permeability.

U.S. Patent No. 4,290,209 discloses the use of flat monofilament warp yarns woven contiguous with each other to provide a fabric with reduced permeability. However, even where flat warp yarns are woven contiguous with each other, additional means, such as stuffer yarns, are required to reduce the permeability of the fabric. As pointed out in that patent, it is desirable to avoid the use of fluffy, bulky stuffer yarns to reduce permeability which make the fabric susceptible to picking up foreign substances or retaining water.

U.S. Patent No. 4,290,209 and U.S. Patent No. 4,755,420 note practical limitations in the aspect ratio (cross-sectional width to height ratio) of machine direction warp yarns defining the structural weave of a fabric. The highest practical aspect ratio disclosed in those patents is 3:1, and the aspect ratio is preferably, less than 2:1.

U.S. Patent No. 4,621,663, assigned to the assignee of the present invention, discloses one attempt to utilize high aspect ratio yarns (on the order of 5:1 and above) to define the surface of a papermakers dryer fabric. As disclosed in that patent, a woven base fabric is provided to support the high aspect ratio surface yarns. The woven base fabric is comprised of conventional round yarns and provides structural support and stability to the fabric disclosed in that patent.

U.S. Patent No. 4,815,499 discloses the use of flat yarns in the context of a forming fabric. That patent discloses a composite fabric comprised of an upper fabric and a lower fabric tied together by binder yarns. The aspect ratio employed for the flat machine direction yarns in both the upper and lower fabrics are well under 3:1.

In use, papermakers fabrics are configured as endless belts. Weaving techniques are available to initially weave fabrics endless. However, there are practical limitations on the overall size of endless woven fabrics as well as inherent installation difficulties. Moreover, not all papermaking equipment is designed to accept the installation of an endless fabric.

Flat woven fabrics are often supplied having opposing ends which are seamed together during installation of the fabric on papermaking equipment. Usually one end of the fabric is threaded through the serpentine path defined by the papermaking equipment and is then joined to its opposing end to form a continuous belt.

A variety of seaming techniques are well known in the art. One conventional method of seaming is to form the machine direction yarns on each end of the fabric into a series of loops. The loops of the respective fabric ends are then intermeshed during fabric installation to define a channel through which a pintle is inserted to lock the ends together.

For example, U.S. Patent Nos. 4,026,331; 4,438,789 which discloses the features of the pre-characterising part of Claim 1; 4,469,142; 4,846,231; 4,824,525 and 4,883,096 disclose a variety of pin seams wherein the machine direction yarns are utilized to form the end loops. In each of those patents, however, the machine direction yarn projects from the end of the fabric and weaves back into the fabric adjacent to itself. Accordingly, the loops inherently have a twist or torque factor and are not entirely orthogonal to the plane of the fabric. U.S. Patent 4,883,096 specifically addresses this problem.

It would be desirable to provide a papermakers fabric with machine direction seaming loops which do not have torque and/or twist.

The present invention seeks to provide such a fabric.

According to the invention, there is provided an industrial fabric, for example a papermakers fabric, having opposing ends comprising a system of flat monofilament MD yarns interwoven with a system of CMD yarns characterised in that:

said MD yarns comprise pairs of vertically aligned upper and lower MD yarns with selected lower MD yarns being trimmed back a selected distance from the ends of the fabric; and

a series of orthogonal end loops are formed on each end of said fabric from selected upper MD yarns which are looped back and interwoven with said CMD yarns directly beneath themselves in the space vacated by the respective trimmed lower MD yarns.

At least the upper MD yarns are flat monofilament yarns woven continuous with each other to reduce the permeability of the fabric and to lock in the machine direction alignment of the stacking pairs of MD yarns. In the preferred embodiment, the same type and size yarns are used throughout the machine direction yarn system and both the top and the bottom MD yarns weave contiguously with adjacent top and bottom MD yarns, respectively. The stacked, contiguous woven machine direction system provides stability and permits the MD yarns to have a relatively high aspect ratio, cross-sectional width to height, of greater than 3:1.; the aspect ratio preferably ranging from about 2:1 to 6:1. The machine direction yarns further define a series of orthogonal seaming loops on the opposing fabric ends. End segments of the lower MD yarns are removed and the upper MD yarn ends are looped back upon themselves and rewoven into the fabric end in the space vacated by the trimmed lower MD yarn end segments. The lower MD yarns may weave in an inverted image of the upper MD yarns such that the crimp of the upper MD yarns conforms with the lower MD yarn weave pattern space into which the upper MD yarn ends are backwoven. This improves the strength of the seam.

Non-loop forming upper MD yarns are also preferably backwoven into the space vacated by trimming the respective lower MD yarns. Preferably, at least the upper MD yarns are woven contiguous with each other to lock in the machine direction alignment of the stacking pairs of MD yarns and the orthogonal orientation of the end loops. In the preferred embodiment, the same type of material and the same geometric shape and size yarns are used throughout the machine direction yarn system and both the top and the bottom MD yarns weave contiguously with adjacent top and bottom MD yarns, respectively.

In order that the invention may be better understood, several embodiments thereof will now be described, by way of example only, and with reference to the accompanying drawings . It should be noted that the present application is a divisional application of application No. 91907325.4 (European Patent No. 0532510) and, in order to maintain the continuity of the original text, and to provide a background for a full understanding of the invention claimed herein, no amendment has been made to the following text. However, it should be made clear that the particular features of the invention claimed herein are illustrated primarily with reference to Figures 4, 5, 10 and 11, and references in the following to embodiments of the invention, or the like, should be construed accordingly.

In the accompanying drawings:

Figure 1 is a schematic diagram of a papermakers fabric made in accordance with the teachings of the present invention;
Figure 2 is a cross-sectional view of the fabric depicted in Figure 1 along line 2-2;
Figure 3a is a cross-sectional view of the fabric depicted in Figure 1 along line 3-3;
Figure 3b is a cross-sectional view of a prior art weave construction;
Figure 4a illustrates the yarn orientation in the fabric depicted in Figure 1 after the fabric is finished showing only two representative stacked MD yarns;
Figures 4b, 4c and 4d are a series of illustrations showing the formation of a seaming loop for the papermakers fabric depicted in Figure 1;
Figure 5a is a perspective view of a prior art MD yarn seaming loop;
Figure 5b is a perspective view of an orthogonal MD yarn seaming loop made in accordance with the present invention;
Figure 6 is a schematic view of a second embodiment of a fabric made in accordance with the present invention;
Figure 7 is a cross-sectional view of the fabric depicted in Figure 6 along line 7-7;
Figure 8 is a cross-sectional view of the fabric depicted in Figure 6 along line 8-8;
Figure 9 is a perspective view of a portion of the fabric illustrated in Figures 6-8;
Figure 10 illustrates the yarn orientation in the finished fabric depicted in Figure 6 showing the end loop formed by one of the MD yarns;
Figure 11 is a top view of the opposing ends of a fabric constructed in accordance with Figure 6 just prior to pin-seaming the ends together;
Figure 12 is a schematic view of a third alternate embodiment of a fabric made in accordance with the teachings of the present invention showing only one pair of stacked MD yarns;
Figure 13 is a schematic view of a fourth alternate embodiment of a fabric made in accordance with the teachings of the present invention showing only one pair of stacked MD yarns;
Figure 14 is a schematic view of a fifth alternate embodiment of a fabric made in accordance with the teachings of the present invention showing only one pair of stacked MD yarns;
Figure 15 is a schematic view of a sixth alternate embodiment of a fabric made in accordance with the teachings of the present invention showing only one pair of stacked MD yarns;
Figure 16 is a schematic view of a seventh alternate embodiment of a fabric made in accordance with the teachings of the present invention showing only one pair of stacked MD yarns; and
Figure 17 is a schematic view of a eighth alternate

embodiment of a fabric made in accordance with the teachings of the present invention showing only one pair of stacked MD yarns.

DETAILED DESCRIPTION OF PRESENTLY PREFERRED EMBODIMENTS

Referring to Figures 1, 2, and 3a, there is shown a papermakers dryer fabric 10 comprising upper, middle and lower layers of cross machine direction (hereinafter CMD) yarns 11, 12, 13, respectively, interwoven with a system of MD yarns 14-19 which sequentially weave in a selected repeat pattern. The MD yarn system comprises upper MD yarns 14, 16, 18 which interweave with CMD yarns 11, 12 and lower MD yarns 15, 17, 19 which interweave with CMD yarns 12, 13.

The upper MD yarns 14, 16, 18 define floats on the top surface of the fabric 10 by weaving over two upper layer CMD yarns 11 dropping into the fabric to weave in an interior knuckle under one middle layer CMD yarn 12 and under one CMD yarn 11 and thereafter rising to the surface of the fabric to continue the repeat of the yarn. The floats over upper layer CMD yarns 11 of upper MD yarns 14, 16, 18 are staggered so that all of the upper and middle layer CMD yarns 11, 12 are maintained in the weave.

As will be recognized by those skilled in the art, the disclosed weave pattern with respect to Figures 1, 2, and 3a, results in the top surface of the fabric having a twill pattern. Although the two-float twill pattern represented in Figures 1, 2, and 3a is a preferred embodiment, it will be recognized by those of ordinary skill in the art that the length of the float, the number of MD yarns in the repeat, and the ordering of the MD yarns may be selected as desired so that other patterns, twill or non-twill, are produced.

As best seen in Figures 2 and 3a, lower MD yarns 15, 17, 19, weave directly beneath upper MD yarns 14, 16, 18, respectively, in a vertically stacked relationship. The lower yarns weave in an inverted image of their respective upper yarns. Each lower MD yarn 15, 17, 19 floats under two lower layer CMD yarns 13, rises into the fabric over one CMD yarn 13 and forms a knuckle around one middle layer CMD yarn 12 whereafter the yarn returns to the lower fabric surface to continue its repeat floating under the next two lower layer CMD yarns 13.

With respect to each pair of stacked yarns, the interior knuckle, formed around the middle layer CMD yarns 12 by one MD yarn, is hidden by the float of the other MD yarn. For example, in Figures 1 and 3a, lower MD yarn 15 is depicted weaving a knuckle over CMD yarn 12 while MD yarn 14 is weaving its float over CMD yarns 11, thereby hiding the interior knuckle of lower MD yarn 15. Likewise, with respect to Figures 1 and 3a, upper MD yarn 18 is depicted weaving a knuckle under yarn CMD yarn 12 while it is hidden by lower MD yarn 19 as it floats under CMD yarns 13.

The upper MD yarns 14, 16, 18, are woven contiguous with respect to each other. This maintains their respective parallel machine direction alignment and reduces permeability. Such close weaving of machine direction yarns is known in the art as 100% warp fill as explained in U.S. Patent No. 4,290,209. As taught therein (and used herein), actual warp count in a woven fabric may vary between about 80%-125% in a single layer and still be considered 100% warp fill.

The crowding of MD yarns 14, 16, and 18 also serves to force MD yarns 15, 17, 19, into their stacked position beneath respective MD yarns 14, 16, 18. Preferably MD yarns 15, 17, and 19 are the same size as MD yarns 14, 16, and 18 so that they are likewise woven 100% warp fill. This results in the overall fabric of the preferred embodiment having 200% warp fill of MD yarns.

Since the lower MD yarns 15, 17, 19 are also preferably woven 100% warp fill, they likewise have the effect of maintaining the upper MD yarns 14, 16, 18 in stacked relationship with the respect to lower MD yarns 15, 17, 19. Accordingly, the respective MD yarn pairs 14 and 15, 16 and 17, 18 and 19 are doubly locked into position thereby enhancing the stability of the fabric.

As set forth in the U.S. Patent No. 4,290,209, it has been recognized that machine direction flat yarns will weave in closer contact around cross machine direction yarns than round yarns. However, a 3:1 aspect ratio was viewed as a practical limit for such woven yarns in order to preserve overall fabric stability. The present stacked MD yarn system preserves the stability and machine direction strength of the fabric and enables the usage of yarns with increased aspect ratio, in a preferred range of 2:1 to 6:1, to more effectively control permeability.

The high aspect ratio of the MD yarns translates into reduced permeability. High aspect ratio yarns are wider and thinner than conventional flat yarns which have aspect ratios less than 3:1 and the same cross-sectional area. Equal cross-sectional area means that comparable yarns have substantially the same linear strength. The greater width of the high aspect ratio yarns translates into fewer interstices over the width of the fabric than with conventional yarns so that fewer openings exist in the fabric through which fluids may flow. The relative thinness of the high aspect ratio yarns enables the flat MD yarns to more efficiently cradle, i.e. brace, the cross machine direction yarns to reduce the size of the interstices between machine direction and cross machine direction yarns.

For example, as illustrated in Figure 3b, a fabric woven with a single layer system of a flat machine direction warp having a cross-sectional width of 1.5 units and a cross-sectional height of 1 unit, i.e. an aspect ratio of 1.5:1, is shown. Such fabric could be replaced by a fabric having the present dual stacked MD yarn system with MD yarns which are twice the width, i.e. 3 units, and half the height, i.e. 0.5 units. Such MD yarns thusly having a fourfold greater aspect ratio of 6:1, as illustrated in Fig-

ure 3a.

The thinner, wider MD yarns more efficiently control permeability while the machine direction strength of the fabric remains essentially unaltered since the cross-sectional area of the MD yarns over the width of the fabric remains the same. For the above example, illustrated by Figures 3a and 3b, the conventional single MD yarn system fabric has six conventional contiguous flat yarns over 9 units of the fabric width having a cross-sectional area of 9 square units, i.e. 6∗(1u.∗1.5u.) . The thinner, wider high aspect ratio yarns, woven as contiguous stacked MD yarns, define a fabric which has three stacked pairs of MD yarns over 9 units of fabric width. Thus such fabric also has a cross-sectional area of 9 square units, i.e.(3*(0.5u.*3u.)) + (3*(0.5u.*3u.)) , over 9 units of fabric width.

In one example, a fabric was woven in accordance with Figures 1, 2 and 3, wherein the CMD yarns 11, 12, 13 were polyester monofilament yarns 0.6mm in diameter interwoven with MD yarns 14-19 which were flat polyester monofilament yarns having a width of 1.12mm and a height of 0.2mm. Accordingly, the aspect ratio of the flat MD yarns was 5.6:1. The fabric was woven at 48 warp ends per inch with a loom tension of 40 PLI (pounds per linear inch) and 12.5 CMD pick yarns per inch per layer (three layers).

The fabric was heat set in a conventional heat setting apparatus under conditions of temperature, tension and time within known ranges for polyester monofilament yarns. For example, conventional polyester fabrics are heat set within parameters of 340°F-380°F temperature, 6-15 PLI (pounds per linear inch) tension, and 3-4 minutes time. However, due to their stable structure, the fabrics of the present invention are more tolerant to variations in heat setting parameters.

The fabric exhibited a warp modulus of 6000 PSI (pounds per square inch) measured by the ASTM D-1682-64 standard of the American Society for Testing and Materials. The fabric stretched less that 0.2% in length during heat setting. This result renders the manufacture of fabrics in accordance with the teachings of the present invention very reliable in achieving desired dimensional characteristic as compared to conventional fabrics.

The resultant heat set fabric had 12.5 CMD yarns per inch per layer with 106% MD warp fill with respect to both upper and lower MD yarns resulting in 212% actual warp fill for the fabric. The finished fabric has a permeability of 83CFM as measured by the ASTM D-737-75 standard.

As illustrated in Figure 4a, when the fabric 10 is woven the three layers of CMD yarns 11, 12, 13 become compressed. This compression along with the relatively thin dimension of the MD yarns reduces the caliper of the fabric. Accordingly, the overall caliper of the fabric can be maintained relatively low and not significantly greater than conventional fabrics woven without stacked MD yarn pairs. In the above example, the caliper of the finished fabric was 0.050 inches.

It will be recognized by those of ordinary skill in the art that if either top MD yarns 14, 16, 18 or bottom MD yarns 15, 17, 19 are woven at 100% warp fill, the overall warp fill for the stacked fabric will be significantly greater than 100% which will contribute to the reduction of permeability of the fabric. The instant fabric having stacked MD yarns will be recognized as having a significantly greater percentage of a warp fill than fabrics which have an actual warp fill of 125% of non-stacked MD yarns brought about by crowding and lateral undulation of the warp strands. Although the 200% warp fill is preferred, a fabric may be woven having 100% fill for either the upper or lower MD yarns with a lesser degree of fill for the other MD yarns by utilizing yarns which are not as wide as those MD yarns woven at 100% warp fill. For example, upper yarns 14, 16, 18 could be 1 unit wide with lower layer yarns 15, 17, 19 being .75 units wide which would result in a fabric having approximately 175% warp fill.

Such variations can be used to achieve a selected degree of permeability. Alternatively, such variations could be employed to make a forming fabric. In such a case, the lower MD yarns would be woven 100% warp fill to define the machine side of the fabric and the upper MD yarns would be woven at a substantially lower percentage of fill to provide a more open paper forming surface.

The stacked pair MD weave permits the formation of orthogonal seaming loops within MD yarns. With reference to Figures 4a-d, after the fabric has been woven and heat set (Figure 4a), CMD yarns are removed leaving the crimped MD yarns 14, 15 exposed (Figure 4b). One of the yarns, for example, MD lower yarn 15, of the stacked pair is trimmed back a selected distance leaving the other exposed MD yarn 14 of the MD yarn pair and vacated space between the CMD yarns, as illustrated in Figure 4c. Upper MD yarn 14 is then backwoven into the space vacated in the weave pattern by lower MD yarn 15 such that a loop L is formed on the end of the fabric, as illustrated in Figure 4d. Preferably, between 0.5 - 5.0 inches of upper layer yarn 14 is backwoven into the fabric to provide sufficient strength for the end loop and assure retention of the free end of MD yarn 14 within the weave of the fabric. The inverted image weave permits the crimp of the upper MD yarn 14 to match the space vacated by the lower MD yarn 15 which further enhances the strength of the end loop.

As shown in phantom in Figure 4d, adjacent yarn pair 16, 17 is processed in a similar manner. However, when upper yarn 16 is looped back and backwoven in the fabric, it is pulled against the CMD yarns. In the preferred embodiment, wherein the upper MD yarns are woven 100% fill, the crowding of the yarns secure the orthogonal orientation of the seaming loops.

To achieve a uniform seam for a fabric woven in accordance with the weave pattern depicted in Figure 1, each upper MD yarn 14 forms a loop and the other upper

MD yarns 16, 18 are backwoven against the endmost CMD yarn of the fabric. Thus every third upper MD yarn defines a loop such that an array of loops is created on each end of the fabric. The seam is assembled by intermeshing the opposing arrays of loops and inserting a pintle yarn between the intermeshed loops.

Preferably, loop forming yarns 14 would all be backwoven approximately the same distance within the fabric to provide sufficient strength to prevent the loops from being pulled apart during normal usage. Non-loop forming yarns 16, 18, would preferably be backwoven a somewhat shorter distance since during usage no load is imparted to those yarns. For example, upper MD yarns 14 would be backwoven approximately 3 inches, MD yarns 16 would be backwoven approximately 2 inches, and MD yarns 18 would be backwoven approximately 1 inch. Respective lower layer yarns 15, 17, 19 would be trimmed to complement the backweaving of their respective MD yarn pair yarns 14, 16, 18.

Figures 5a and 5b, respectively, illustrate a conventional seaming loop 50 in comparison with an orthogonal seaming loop L of the present invention. In conventional loop forming techniques, the MD yarn 51 is backwoven into the fabric adjacent to itself thereby inherently imparting twist and/or torque to the loop structure 50. In the present invention, the MD yarn is looped directly beneath itself and does not have any lateral offset which would impart such twist or torque to the seaming loop.

Referring to Figures 6, 7 and 8, there is shown a second preferred embodiment of a fabric 20 made in accordance with the teachings of the present invention. Papermakers fabric 20 is comprised of a single layer of CMD yarns 21a, 21b interwoven with a system of stacked MD yarns 22-25 which weave in a selected repeat pattern. The MD yarn system comprises upper MD yarns 22, 24 which define floats on the top surface of the fabric 20 by weaving over three CMD yarns, under the next one CMD yarn 21a to form a knuckle, and thereafter returning to float over the next three CMD yarns in a continuation of the repeat.

Lower MD yarns 23, 25, weave directly beneath respective upper MD yarns 22, 24 in a vertically stacked relationship. The lower MD yarns weave in an inverted image of their respective upper MD yarns. Each lower MD yarn 23, 25 floats under three CMD yarns, weaves upwardly around the next one CMD yarn 21a forming a knuckle and thereafter continues in the repeat to float under the next three CMD yarns.

As can be seen with respect to Figures 6 and 8, the knuckles formed by the lower MD yarns 23, 25 are hidden by the floats defined by the upper MD yarns 22, 24 respectively. Likewise the knuckles formed by the upper MD yarns 22, 24 are hidden by the floats of the lower MD yarns 23, 25 respectively.

The caliper of the fabric proximate the knuckle area shown in Figure 8, has a tendency to be somewhat greater than the caliper of the fabric at non-knuckle CMD yarns 21b, shown in Figure 7. However, the CMD yarns 21a around which the knuckles are formed become crimped which reduces the caliper of the fabric in that area as illustrated in Figure 8. Additionally, slightly larger diameter CMD yarns are preferably used for CMD yarns 21b, shown in Figure 7, which are not woven around as knuckles by the MD yarns to eliminate any difference in fabric caliber. Preferably the diameter of the larger CMD yarn 21b equals the diameter d of the smaller CMD yarns 21a plus the thickness t of the MD yarns.

In one example, a fabric was woven in accordance with Figures 6-9, wherein the CMD yarns 21a, 21b were polyester monofilament yarns 0.6mm and 0.8mm, respectively, in diameter interwoven with MD yarns 22-25 which were flat polyester monofilament yarns having a width of 1.12mm and a height of 0.2mm. Accordingly, the aspect ratio of the flat MD yarns was 5.6:1. The fabric was woven at 48 total warp ends per inch with a loom tension of 40 PLI (pounds per linear inch) and 20 CMD total pick yarns per inch. The permeability averaged 90 CFM in the resultant fabric.

In another example, fabric was woven in accordance with Figures 6, 7 and 8, wherein the CMD yarns 21a, 21b were polyester monofilament yarns 0.7mm in diameter interwoven with MD yarns 22-25 which were flat polyester monofilament yarns having a width of 1.12mm and a height of 0.2mm. Accordingly, the aspect ratio of the flat MD yarns was 5.6:1. The fabric was woven at 22 CMD pick yarns per inch. The fabric was heat set using conventional methods. The fabric exhibited a modulus of 6000 PSI. The fabric stretched less than 0.2% in length during heat setting. The resultant fabric had 22 CMD yarns per inch with 106% MD warp fill with respect to both upper and lower MD yarns resulting in 212% actual warp fill for the fabric. The finished fabric had a caliper of .048 inches and an air permeability of 60CFM.

As best shown in Figure 9, the high aspect ratio yarns 22-24 effectively brace the CMD yarns 21a in the weave construction. This bracing effect can be quantified in terms of the degree of contact arc θ and contact bracing area, CBA, as follows:

$$CBA = \pi\, d\, \left(\frac{\theta}{360^\circ}\right) w$$

where

- d = diameter of the CMD yarn
- θ = the degree of arc over which there is contact between the MD and CMD yarns
- w = width of the MD yarn
- π = the constant pi.

The degrees of arc over which MD yarns 22-25 are in contact with CMD yarns 21a is dependent upon the spacing of the CMD yarns within the weave. For the above example, employing alternating 0.6mm and 0.8mm diameter CMD yarns with 0.2mm thick MD yarns,

the degree of contact arc can be maintained in a preferred range of between 60° to 180° by varying the pick count of the CMD yarns from 14 picks per inch to a maximum of 28.22 picks per inch.

In the preferred embodiment where the pick count is 20 picks per inch, the degree of contact arc θ is approximately 101°. This results in a bracing contact area of approximately 0.79mm^2 at each knuckle in the fabric.

Applicant's use of high ratio aspect yarns, i.e. yarns having a width:thickness ratio of at least 3:1, provides for increased bracing contact of the flat MD yarns with the CMD yarns 21a. This is comparatively exemplified by modifying the equation for contact bracing area, CBA, to be defined in terms of the thickness of the MD yarns.

Since the MD yarn width w equals the thickness t of the MD yarn multiplied by the aspect ratio, w > 3t for yarns having an aspect ratio greater than 3:1. Accordingly, fabrics made in accordance with the teachings of the present invention utilizing high aspect ratio MD yarns exhibit enhanced bracing of the CMD yarns by the MD yarns such that:

$$CBA > \pi\, d\, (\frac{\theta}{360°})\, 3t.$$

As best seen in Figure 10, seaming loops are formed by upper MD yarns 22. The respective lower MD yarns 23 are trimmed a selected distance from the fabric end and the upper MD yarns 22 are backwoven into the space vacated by the trimmed lower MD yarns 23.

Upper MD yarns 24 are similarly backwoven into the space vacated by trimming back lower MD yarns 25. However, as best seen in Figure 10, upper MD yarns 24 are backwoven against the endmost CMD yarn 21b.

As illustrated in Figure 11, a series of seaming loops is formed on each of the opposing fabric ends 27, 28. When the fabric is installed on papermaking equipment, the respective end loops formed by MD yarns 22 are intermeshed and a pintle 30 is inserted therethrough to lock the intermeshed series of loops together.

Since the seaming loops L are formed by backweaving MD yarns 22 directly beneath themselves, no lateral twist or torque is imparted on the loop and the loops are orthogonal with the plane of the fabric. This facilitates the intermeshing of the loop series of the opposing fabric ends 27, 28. The orthogonal loops are particularly advantageous where, as shown in Figure 10, the MD yarns 22, 24 are 100% warp fill and adjacent loops are separated by individual MD yarns of the same width as the loop MD yarns 22. Lateral torque or twist on the seaming loops make the seaming process more difficult particularly where the loop-receiving gaps between the loops of one fabric end are essentially the same width as the loops on the opposing fabric end and vice versa.

With reference to the fabric depicted in Figures 6-11, the loop forming MD yarns 22 are preferably backwoven approximately 2 inches while the non-loop forming MD yarns 24 are preferably backwoven 1 inch.

With reference to Figure 12, a third embodiment of a papermakers fabric 30 is shown. Fabric 30 comprises a single layer of CMD yarns 31 interwoven with stacked pairs of flat monofilament yarns in a selected repeat pattern. For clarity, only one pair of stacked MD yarns is shown comprising upper MD yarn 32 and lower MD yarn 33. The upper MD yarns weave in a float over two CMD yarns 31, form a single knuckle under the next CMD yarn 31 and thereafter repeat. Similarly the lower MD yarns weave in an inverted image of the upper MD yarns weaving under two CMD yarns 31, forming a knuckle over the next CMD yarn 31 and then returning to the bottom surface of the fabric in the repeat. Since the repeat of both the upper and lower MD yarns is with respect to three CMD yarns 31, a total of three different stacked pairs of yarns comprise the weave pattern of the MD yarn system.

A fabric was woven in accordance with Figure 12 wherein the CMD yarns 31 were polyester monofilament yarns 0.7mm in diameter interwoven with MD yarns which were flat polyester monofilament yarns having a width of 1.12mm and a height of 0.2mm. Accordingly, the aspect ratio of the flat MD yarns was 5.6:1. The fabric was woven 48 warp ends per inch under a loom tension of 60 PLI and 18 CMD pick yarns per inch. The fabric was heat set using conventional methods. The fabric exhibited amodulus of 6000 PSI. The fabric stretched less than 0.2% in length during heat setting. The resultant fabric had 18 CMD yarns per inch with 106% MD warp fill with respect to both upper and lower MD yarns resulting in 212% actual warp fill for the fabric. The finished fabric having a caliper of 0.046 inches and an air permeability of 66CFM.

With reference to Figure 13, a fourth embodiment of a papermakers fabric 40 is shown. Fabric 40 comprises upper, middle and lower layers of CMD yarns 41, 42, 43, respectively, interwoven with stacked pairs of flat monofilament yarns in a selected repeat pattern. For clarity, only one pair of stacked MD yarns is shown comprising upper MD yarn 44 and lower MD yarn 45. The upper MD yarns weave in a float over two upper layer CMD yarns 41, under the next yarn 41 and a middle layer yarn 42 to form a single knuckle, under the next CMD yarn 41 and thereafter rise to the top surface to continue to repeat. Similarly, the lower MD yarns weave in an inverted image of the upper MD yarns weaving under two lower layer CMD yarns 43 over the next CMD yarn 43 and a middle CMD yarn 42 forming a knuckle, over the next CMD yarn 43 then returning to the bottom surface of the fabric to repeat. Since the repeat of both the upper and lower MD yarns is with respect to four upper and lower CMD yarns 41, 43, respectively, a total of four different stacked pairs of yarns comprise the weave pattern of the MD yarn system.

A fabric was woven in accordance with Figure 13, wherein the upper and lower layer CMD yarns 41, 43

were nylon-sheathed, multifilament polyester yarns 0.62mm in diameter and the middle layer CMD yarns 42 were polyester monofilament yarns 0.5mm in diameter interwoven with MD yarns 22-25 which were flat polyester monofilament yarns having a width of 0.60mm and a height of 0.38mm. Accordingly, the aspect ratio of the flat MD yarns was 1.58:1. The fabric was woven with 96 warp ends per inch under a loom tension of 40 PLI and 15 CMD pick yarns per inch per layer. The fabric was heat set using conventional methods. The resultant fabric had 15 CMD yarns per inch per layer with 113% MD warp fill with respect to both upper and lower MD yarns resulting in 226% actual warp fill for the fabric. The finished fabric had a caliper of .075 inches and an air permeability of 60CFM.

Figures 14, 15 and 16 illustrate the fifth, sixth and seventh embodiments of the present invention. Figure 14 illustrates the weave of a relatively long float on both sides of the fabric; Figure 15 illustrates how a stacked pair MD yarn weave can define floats of different lengths on opposite sides of the fabric; and Figure 16 illustrates how a stacked pair MD yarn weave can be used to construct fabrics having MD knuckles on one side of the fabric.

Relatively long floats predominating the surfaces of a dryer fabric are beneficial for both the paper-carrying side as well as the machine side of the fabric. On the paper-carrying side, long floats provide greater contact area with the paper sheet for increased heat transfer. On the machine side, long floats provide increased wear surface and contact area to reduce bounce and flutter. The stacked pair MD yarn weave is versatile in allowing different surfaces to be defined on the top and bottom sides of the fabric. Accordingly, fabrics made in accordance with the teachings of the present invention may be used for other industrial purposes such as in the drying of sludge.

With respect to Figure 14, a fabric 50 is illustrated comprising three layers of yarns 51, 52, and 53 respectively. In this construction, the MD yarn pairs, such as the pair formed by upper layer yarn 54 and lower layer yarn 55, define relatively long floats on both the top and bottom surfaces of the fabric. Upper yarn 54 weaves over five upper layer CMD yarns 51, drops into the fabric to form a knuckle under one middle layer CMD yarn 52, weaves under the next upper layer yarn 51 and thereafter repeats. Lower MD yarn 55 weaves in an inverted image under five lower layer CMD yarns 53, rising into the fabric over the next CMD 53 to weave a knuckle over one middle layer CMD yarn 52 thereafter dropping to the bottom surface of the fabric to continue its repeat. In such a construction, six pairs of stacked MD yarns are utilized in the repeat of the fabric and are sequentially woven in a selected sequence to produce a desired pattern on the surfaces of the fabric which will be predominated by the MD yarn floats.

The embodiment shown in Figure 15 depicts a fabric 60 in which the MD yarns weave with a five-float repeat on the top fabric surface and a two-float repeat on the bottom fabric surface. For example, upper MD yarn 64 interweaves with upper and middle CMD yarns 61, 62 in the same manner that upper MD yarn 54 weaves with respective CMD yarns 51, 52 with respect to fabric 50 in Figure 14. However, lower MD yarn 65, which forms a stacked pair with upper MD yarn 64, weaves in a two-float bottom repeat with respect lower and middle CMD yarns 63, 62. For example, lower MD yarn 65 floats under two lower layer CMD yarns 63, rises above the next CMD yarn 63 to form a knuckle over one middle layer CMD yarn 62 and thereafter drops to the bottom surface of the fabric 60 to continue to repeat. As with the other embodiments discussed above, the interior knuckles formed by the lower MD yarns are hidden by the upper MD yarn of the respective stacked pair and vice-versa.

The construction shown in Figure 15 permits different surfaces to be defined on the top and bottom of the fabric while utilizing the benefits of the stacked MD yarn pairing.

The embodiment shown in Figure 16 discloses another example of a fabric 70 having five-float MD yarns predominating the upper surface of the fabric, but with MD knuckles on the lower surface of the fabric. This type of construction may be advantageously used to construct a forming fabric where the upper fabric surface, having relatively long floats, would be used as the machine side of the fabric and the knuckled lower surface of the fabric would be used as the paper forming side.

Fabric 70 includes three layers of CMD yarns 71, 72, 73 respectively which interweave with stacked pairs of MD yarns to define this construction. Only one pair of stacked MD yarns 74, 75 is depicted for clarity. Upper MD yarn 74 weaves in a five-float pattern with respect to upper and middle layer CMD yarns 71, 72 in the same manner as upper MD yarn 54 with respect to fabric 50 shown in Figure 14. Lower MD yarn 75 weaves three interior knuckles and three lower surface knuckles with respect to middle and lower layer CMD yarns 72, 73 under each upper surface float of its respective MD yarn pair yarn 74. The repeat of the upper MD yarns is defined with respect to six upper layer CMD yarns 71 and the repeat of the lower MD yarns is defined with respect to only two lower layer CMD yarns 73. Accordingly, there are six different pairs of stacked MD yarns which constitute the MD yarn system which, as noted above, can be arranged such that a desired pattern is formed on the upper surface of the fabric.

Generally for stacked pair weaves, the repeat of the upper MD yarns will be equally divisible by, or an equal multiple of, the repeat of the lower MD yarns in defining the stacking pair relationship. For example, with respect to Figure 12 the repeat of the upper MD yarns is six upper layer CMD yarns which is equally divisible by the repeat of the lower MD yarns which is three lower layer CMD yarns.

With respect to the eighth alternate embodiment

shown in Figure 17, a fabric 80 is illustrated having a single layer of CMD yarns 81 and a representative stacked pair of MD yarns 82, 83. Upper MD yarn 82 weaves with two floats over CMD yarns 81 with a repeat occurring with respect to three CMD yarns 81. Lower MD yarn 83 weaves with five floats under CMD yarns 81 with a repeat of six CMD yarns 81. Thus, in fabric 80, the repeat of the upper MD yarns, which is three, is an equal multiple of the repeat of lower MD yarns, which is six.

A variety of other weave patterns employing the paired stacked weave construction of the instant invention may be constructed within the scope of the present invention. For example, in some applications it may be desirable to have MD yarn surface floats over six or more CMD yarns. Such fabrics are readily constructed in accordance with the teachings of the present invention.

Claims

1. An industrial fabric (20), for example a papermakers fabric, having opposing ends comprising a system of flat monofilament MD yarns (22, 23, 24, 25) interwoven with a system of CMD yarns (21a, 21b) characterised in that:

   said MD yarns comprise pairs of vertically aligned upper and lower MD yarns (22 and 23, 24 and 25) with selected lower MD yarns (23) being trimmed back a selected distance from the ends of the fabric; and
   a series of orthogonal end loops are formed on each end of said fabric from selected upper MD yarns (22) which are looped back and interwoven with said CMD yarns (21a, 21b) directly beneath themselves in the space vacated by the respective trimmed lower MD yarns (23).

2. A fabric according to claim 1, wherein said CMD yarn system comprises a single layer of CMD yarns (21a, 21b).

3. A fabric according to claims 1 or 2, wherein at least said upper MD yarns (22) have an aspect ratio of at least 3:1.

4. A fabric according to claim 1, wherein:

   all orthogonal end loop forming upper MD yarns (22) are interwoven with said CMD yarns (21a, 21b) directly beneath themselves;
   all lower MD yarns (23, 25) are trimmed back a selected distance from the ends of the fabric; and
   the remaining upper MD yarns (25) are interwoven with the CMD yarns (21a, 21b) directly beneath themselves and retain the endmost CMD yarns in the fabric.

5. A fabric according to claim 4, wherein:

   the orthogonal end loop forming upper MD yarns (22) are all back woven substantially the same distance into the end of the fabric which distance is greater than the back weaving of the remaining upper MD yarns (24); and
   the lower MD yarns (23) which are paired with loop forming upper MD yarns (22) are trimmed back a greater distance from the end of the fabric than the remaining lower MD yarns (25).

6. A fabric according to claim 4, wherein the actual warp fill of at least said upper MD yarns (22, 24) is in the range of 80%-125%.

7. A fabric according to claim 4, wherein said lower MD yarns (23, 25) are interwoven with said CMD yarns (21a, 21b) in an inverted image of the respective upper MD yarns (22, 24) of said MD yarn pairs.

8. A fabric according to claim 4, wherein every second upper MD yarn on each end of the fabric is an orthogonal loop forming yarn.

9. A fabric according to claim 4, wherein every third upper MD yarn on each end of the fabric is an orthogonal loop forming yarn.

10. A fabric according to claim 1, wherein:

    each opposed end has a first set of said MD yarns (22) looped back and interwoven with said CMD yarns (21a, 21b) directly beneath themselves to define a series of orthogonal end loops; and
    each opposed end has a second set of said MD yarns (24), interspersed between the first set, looped back and interwoven with said CMD yarns (21a, 21b) directly beneath themselves to retain the endmost CMD yarns in the fabric.

Patentansprüche

1. Industrielles Gewebe (20), z.B. ein Papiermaschinengewebe mit entgegengesetzten Enden, die ein System aus flachen Monofilament-MD-Fäden (22, 23, 24, 25) aufweisen, die mit einem System von CMD-Fäden (21a, 21b) verwebt sind,
   dadurch gekennzeichnet, daß

   die MD-Fäden Paare von vertikal ausgerichteten, oberen und unteren MD-Fäden (22 und 23, 24 und 25) mit ausgewählten unteren MD-Fä-

den (23) aufweisen, welche um einen ausgewählten Abstand von den Enden des Gewebes zurückgeschnitten sind, und
eine Serie von orthogonalen Endschleifen an jedem Ende des Gewebes von ausgewählten oberen MD-Fäden (22) gebildet sind, die zurückgeschleift und mit den CMD-Fäden (21a, 21b) direkt unterhalb derselben miteinander im Raum verwebt sind, der durch die entsprechenden geschnittenen unteren MD-Fäden (23) frei geworden ist.

2. Gewebe nach Anspruch 1, bei dem das CMD-Fadensystem eine einzige Schicht von CMD-Fäden (21a, 21b) aufweist.

3. Gewebe nach Anspruch 1 oder 2, bei dem mindestens die oberen MD-Fäden (22) ein Querschnittsverhältnis von mindestens 3:1 haben.

4. Gewebe nach Anspruch 1, bei dem

alle orthogonalen, Endschleifen bildenden oberen MD-Fäden (22) mit den CMD-Fäden (21a, 21b), die unmittelbar unterhalb derselben liegen, verwebt sind,
alle unteren MD-Fäden (23, 25) um einen ausgewählten Abstand gegenüber den Enden des Gewebes zurückgeschnitten sind, und
die übrigen oberen MD-Fäden (25) alle mit den CMD-Fäden (21a, 21b) direkt unterhalb derselben verwebt sind und die die äußersten Enden bildenden CMD-Fäden im Gewebe halten.

5. Gewebe nach Anspruch 4, bei dem

die orthogonalen Endschleifen bildenden oberen MD-Fäden (22) alle im wesentlichen um den gleichen Abstand in das Ende des Gewebes zurückgewebt sind, wobei dieser Abstand größer ist als die Strecke, um die die übrigen oberen MD-Fäden (24) zurückgewebt sind, und die unteren MD-Fäden (23), die paarweise mit Schleifen formenden oberen MD-Fäden (22) angeordnet sind, um einen größeren Abstand von dem Ende des Gewebes zurückgeschnitten sind als die übrigen unteren MD-Fäden (25).

6. Gewebe nach Anspruch 4, bei dem die tatsächliche Kettfüllung mindestens der oberen MD-Fäden (22, 24) im Bereich von 80% - 125% beträgt.

7. Gewebe nach Anspruch 4, bei dem die unteren MD-Fäden (23, 25) mit den CMD-Fäden (21a, 21b) in einem umgekehrten Bild zu den entsprechenden oberen MD-Fäden (22, 24) der MD-Fadenpaare verwebt sind.

8. Gewebe nach Anspruch 4, bei dem jeder zweite obere MD-Faden an jedem Ende des Gewebes ein eine orthogonale Schleife bildender Faden ist.

9. Gewebe nach Anspruch 4, bei dem jeder dritte obere MD-Faden an jedem Ende des Gewebes ein orthogonaler, Schleifen bildender Faden ist.

10. Gewebe nach Anspruch 1, bei dem
jedes entgegengesetzte Ende einen ersten Satz der MD-Fäden (22) aufweist, die zurückgeschleift und mit den CMD-Fäden (21a, 21b) direkt unterhalb derselben verwebt sind, um eine Reihe von orthogonalen Endschleifen auszubilden, und jedes gegenüberliegende Ende einen zweiten Satz von MD-Fäden (24) besitzt, die zwischen dem ersten Satz verteilt sind, zurückgeschleift sind und mit den CMD-Fäden (21a, 21b) direkt unterhalb derselben verwebt sind, um die CMD-Fäden am äußersten Ende in dem Gewebe zu halten.

Revendications

1. Toile industrielle (20), par exemple toile de papetier, présentant des extrémités opposées comprenant un système de fils MD (de sens longitudinal à la machine) monofilaments plats (22, 23, 24, 25), tissé ensemble avec un système de fils CMD (de sens transversal à la machine) (21a, 21b), caractérisée en ce que :

lesdits fils MD comprennent des paires de fils MD supérieurs et inférieurs verticalement alignés (22 et 23, 24 et 25), des fils MD inférieurs choisis (23) étant recoupés d'une distance choisie depuis les extrémités de la toile ; et
une série de boucles d'extrémité orthogonales est formée sur chaque extrémité de ladite toile à partir des fils MD supérieurs (22) choisis qui sont rebouclés et tissés ensemble avec lesdits fils CMD (21a, 21b) directement sous eux-mêmes dans l'espace laissé libre par les fils MD inférieurs (23) coupés respectifs.

2. Toile selon la revendication 1, dans laquelle ledit système de fils CMD comprend une couche unique de fils CMD (21a, 21b).

3. Toile selon la revendication 1 ou la revendication 2, dans laquelle au moins lesdits fils MD supérieurs (22) ont un rapport d'apparence d'au moins 3 : 1.

4. Toile selon la revendication 1, dans laquelle :

tous les fils MD supérieurs (22) de formage de boucle d'extrémité orthogonale sont tissés ensemble avec lesdits fils CMD (21a, 21b) direc-

tement sous eux-mêmes ;
tous les fils MD inférieurs (23, 25) sont recoupés d'une distance choisie depuis les extrémités de la toile ; et
les fils MD supérieurs (25) restants sont tissés ensemble avec les fils CMD (21a, 21b) directement sous eux-mêmes et retiennent les fils CMD les plus éloignés dans la toile.

5. Toile selon la revendication 4, dans laquelle :

les fils MD supérieurs (22) de formage de boucle d'extrémité orthogonale sont tous retissés sensiblement d'une même distance dans l'extrémité de la toile, laquelle distance est supérieure au retissage des fils MD supérieurs (24) restants ; et
les fils MD inférieurs (23) qui sont appariés avec les fils MD supérieurs (22) de formage de boucle sont recoupés d'une distance depuis l'extrémité de la toile, supérieure aux fils MD inférieurs (25) restants.

6. Toile selon la revendication 4, dans laquelle le taux de remplissage de chaîne réel, au moins desdits fils MD supérieurs (22, 24), est compris dans la plage allant de 80% à 125%.

7. Toile selon la revendication 4, dans laquelle lesdits fils MD inférieurs (23, 25) sont tissés ensemble avec lesdits fils CMD (21a, 21b) selon une image inversée des fils MD supérieurs (22, 24) respectifs de ladite paire de fils MD.

8. Toile selon la revendication 4, dans laquelle chaque deuxième fil MD supérieur, sur chaque extrémité de la toile, est un fil de formage de boucle orthogonale.

9. Toile selon la revendication 4, dans laquelle chaque troisième fil MD supérieur, sur chaque extrémité de la toile, est un fil de formage de boucle orthogonale.

10. Toile selon la revendication 1, dans laquelle :

chaque extrémité opposée présente un premier groupe desdits fils MD (22) rebouclés et tissés ensemble avec lesdits fils CMD (21a, 21b) directement sous eux-mêmes afin de définir une série de boucles d'extrémité orthogonales ; et
chaque extrémité opposée présente un deuxième groupe desdits fils MD (24) entremêlés entre le premier groupe, rebouclés et tissés ensemble avec lesdits fils CMD (21a, 21b) directement sous eux-mêmes pour retenir les fils CMD les plus éloignés dans la toile.

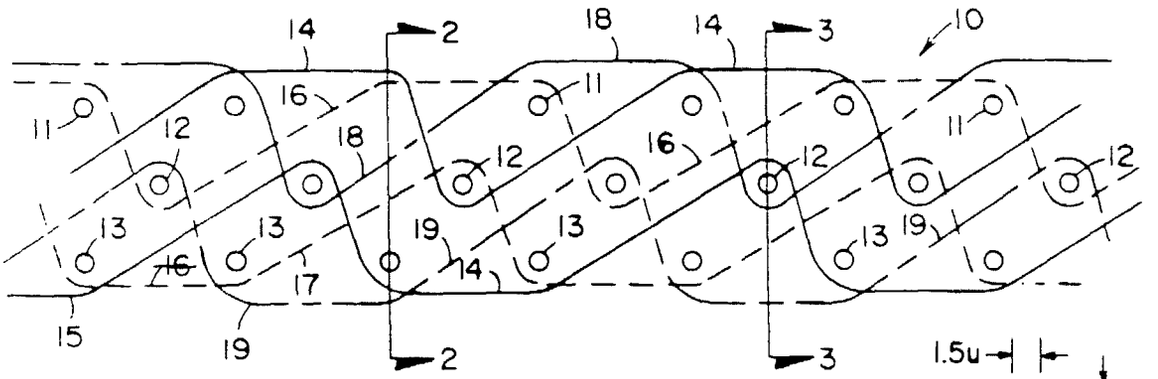


FIG. 1

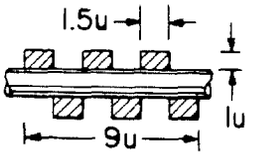


FIG. 3b
PRIOR ART

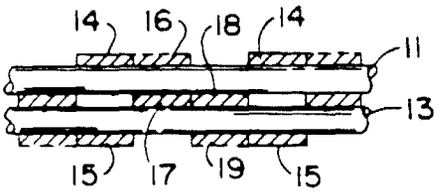


FIG. 2

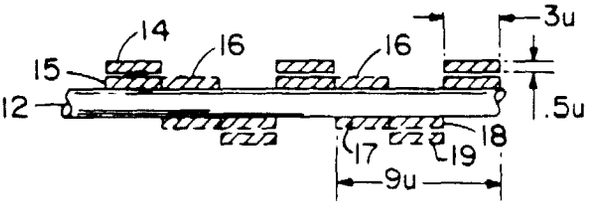


FIG. 3a

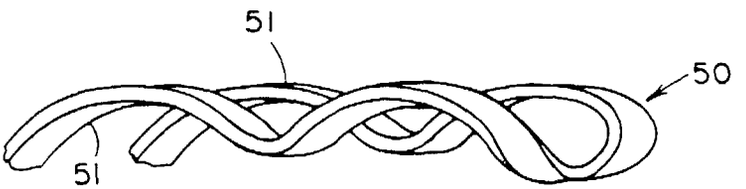


FIG. 5a
(PRIOR ART)



FIG. 5b

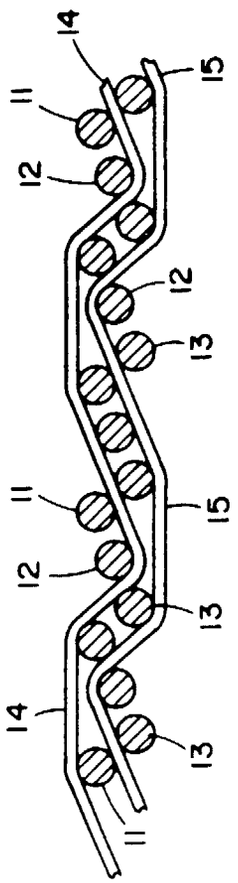


FIG. 4a

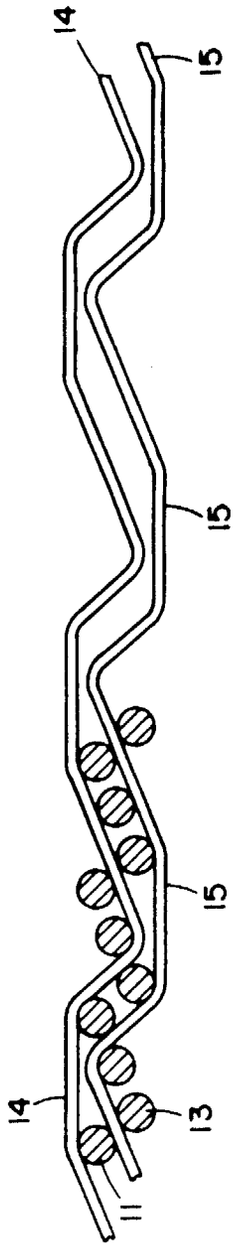


FIG. 4b

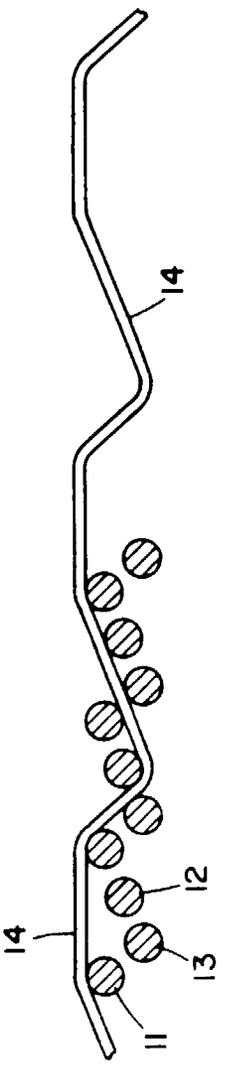


FIG. 4c

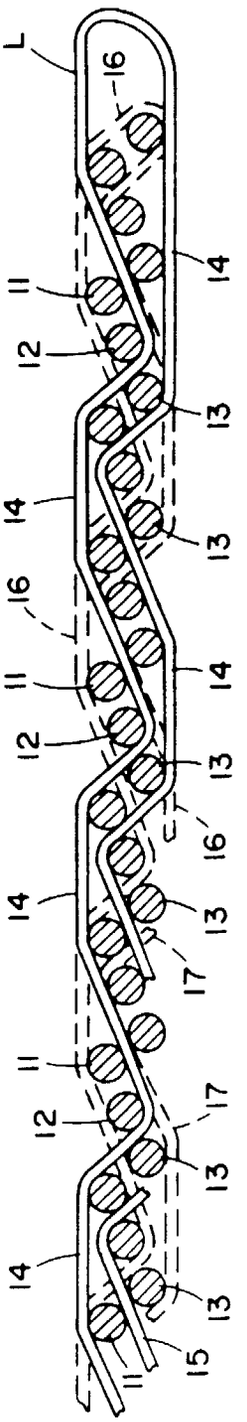


FIG. 4d

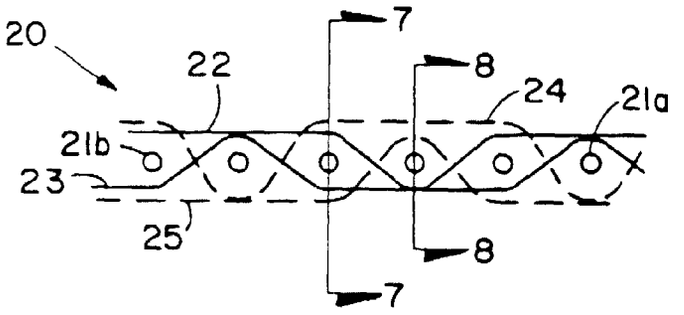


FIG. 6

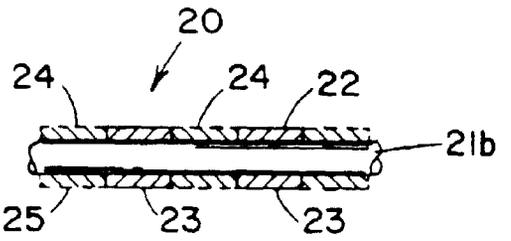


FIG. 7

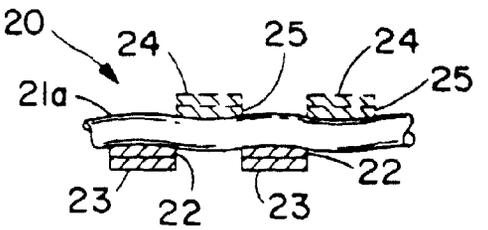


FIG. 8

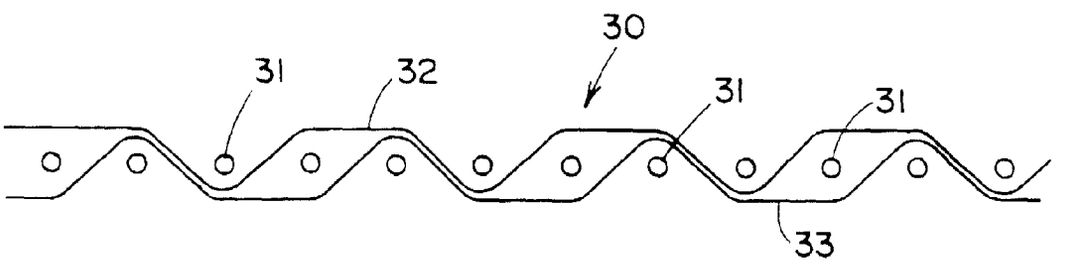
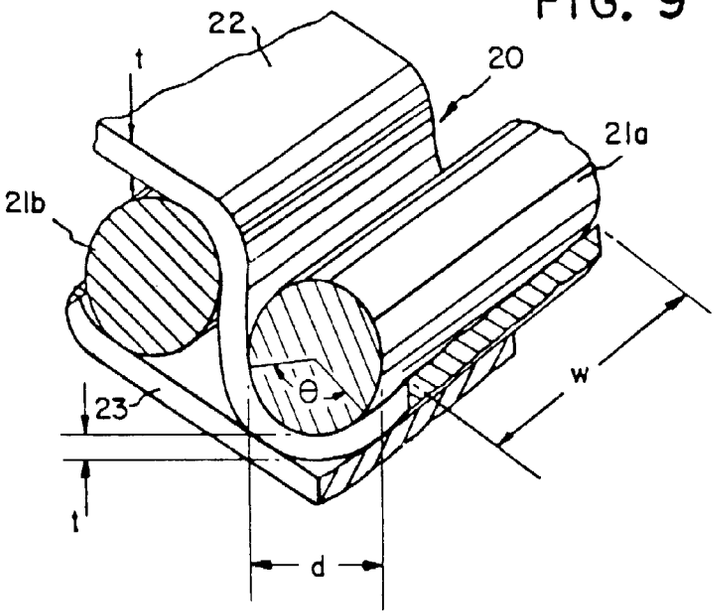


FIG. 12

FIG. 9



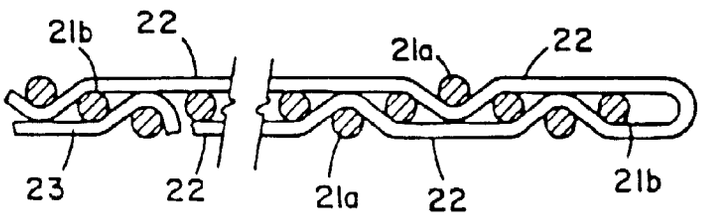
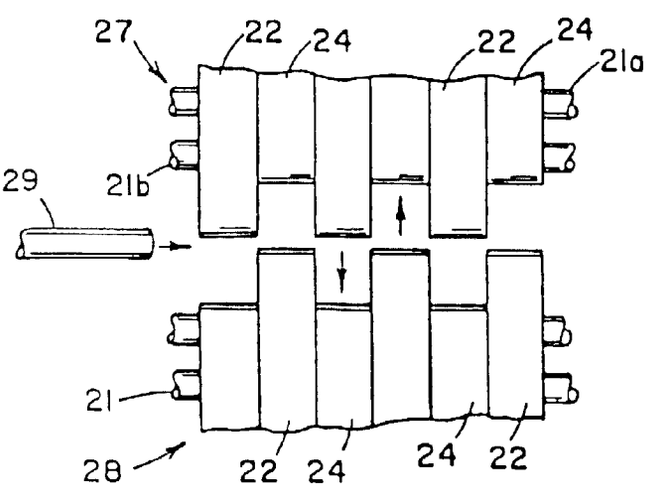


FIG. 10

FIG. 11



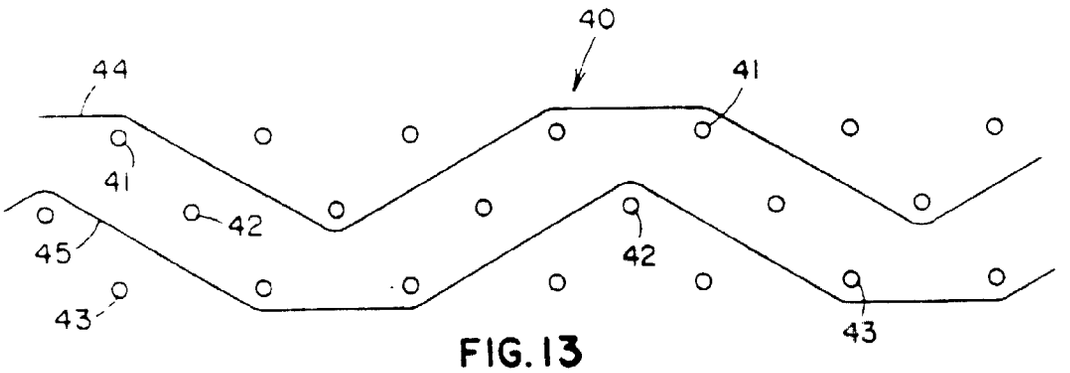


FIG.13

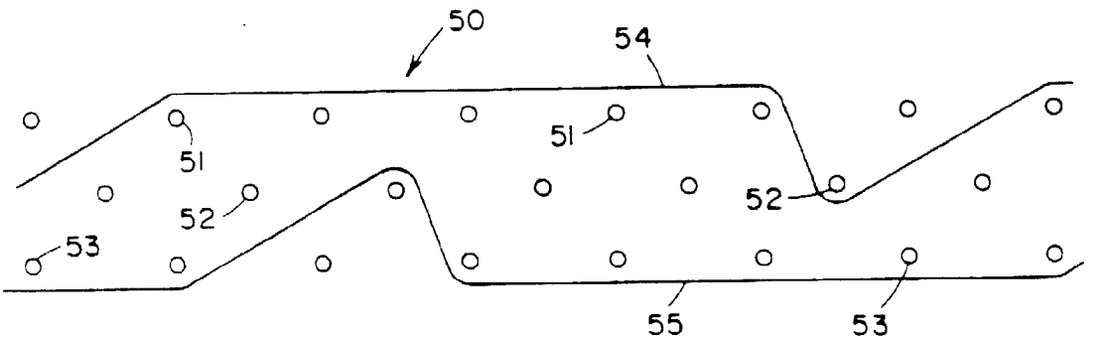


FIG.14

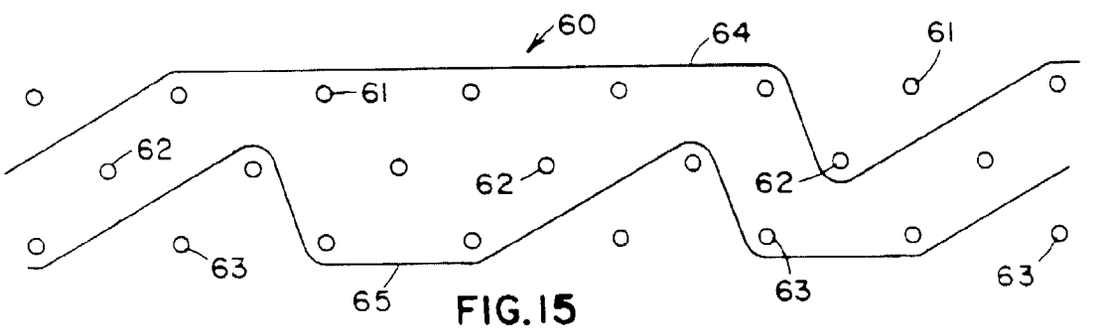


FIG.15

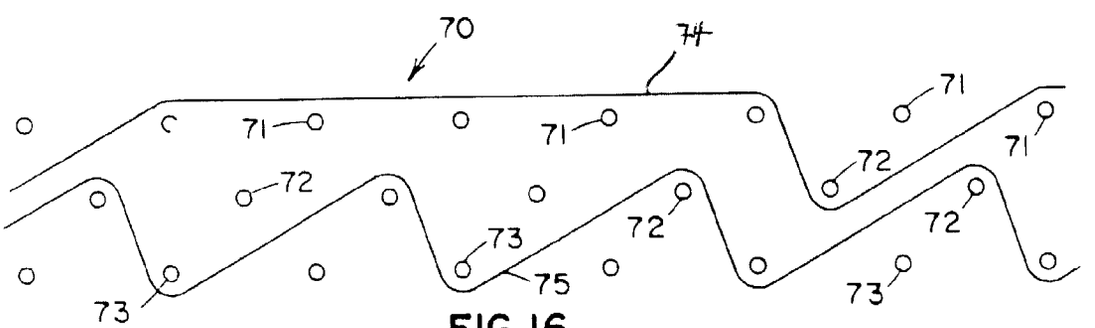


FIG.16

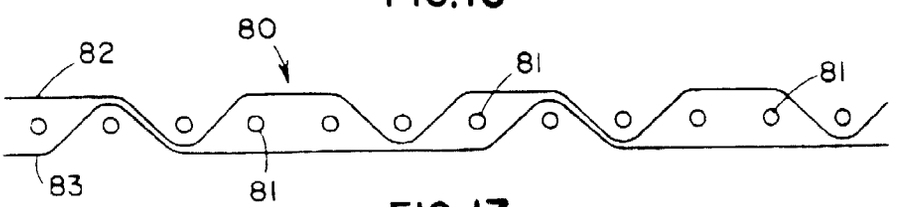


FIG.17