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(54) Novel papermaker's fabrics containing open mesh yarns.

(57) Incompressible open mesh yarns containing a plurality of internal fluid passageways therewith are incorporated into papermaker's forming fabrics, drier fabrics, and press felts to achieve novel fabric constructions with advantages in manufacturing cost savings and performance capability.

FIG. 1

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Huyck Corporation
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NOVEL PAPERMAKER'S FABRICS CONTAINING OPEN MESH YARNS

This invention relates to papermaker's fabrics, in general, and to forming fabrics, dryer fabrics and press felts containing incompressable yarns with an open mesh configuration in particular.

In the manufacture of paper and paperboard, a continuous sheet of cellulosic fiber is formed upon a supporting medium. This sheet initially comprises large quantities of water and has very little strength. Accordingly, it is necessary to provide a carrier for the sheet until sufficient moisture is removed therefrom to provide a self-supporting sheet.

In the paper-making process, the web is formed by depositing the slurry of pulp fibers onto a forming fabric, generally a woven belt of wire and/or synthetic material to form a continuous sheet of paper-like material. A large portion of the water is normally extracted from the web in the forming area by the use of gravity drainage aided by table rolls and suction boxes. The web then passes through a series of press nips formed by cooperating press rolls in the press section, whereby water is pressed from the web, the water being absorbed by the press felt. The paper web is then transferred to a dryer felt in the dryer section of the machine where it is conducted over and between dryer rolls which are heated and which effect removal of most of the remaining water by evaporation.

The current practice in papermaker's forming fabrics is to employ fine woven meshes for fine grade paper, and

coarse woven meshes for coarse or heavyweight sheets of paper. In the case of fine paper grades, a typical forming fabric may contain from one hundred fifty to two hundred total warp and filling yarns per square inch. Fine mesh fabrics are much more costly to produce than coarse mesh fabrics because of the time required to insert each separate filling yarn.

In the case of press felts, it has been found desirable that the sheet contacting surface should be smooth so that the paper sheet is uniformly compressed in the press nip and water from within the sheet can be expressed uniformly into the felt. It is known that the press felt must contain void spaces and interconnected fluid passage-ways for the accommodation and movement of water from the sheet into and through the felt.

Press felts must also maintain their dimensional stability so that throughout life, they do not change in length or width more than can be accommodated on the paper machine. To achieve stability, it is common practice to incorporate a woven base fabric below a sheet contacting needled fibrous batting surface layer. In some cases, the base fabric may be covered with batt on both top and bottom surfaces.

When compressible multifilament or spun yarns are used in the base fabric of a press felt, the resultant felt tends to compact rapidly due to the compressional forces acting upon the felt during repeated passages through the press nip. As a consequence, void space within the felt is reduced, and the felt rapidly loses permeability. For some applications, such loss of void space and permeability leads to premature failure and removal of the felt.

A significant improvement in needled papermakers press felts was the introduction of felts having incompressible

base fabrics. By incompressible base fabric, it is meant that the base fabric resists compaction during operation on the paper machine, retaining a substantial portion of its original thickness and void space for the accommodation of sheet moisture, even after prolonged operation on the paper machine.
Imcompressible base fabrics owe their resistance to compaction to the incorporation and interlacing of incompressible yarns in the woven structure.

If a smooth paper sheet is to be made, it is necessary to cover the incompressible base fabric yarns with enough fibrous batting to insure that a uniform pressure is applied against the sheet. In general, the amount of batting needed to obscure base fabric yarns and weave pattern is proportional to the smoothness of the base fabric. When small incompressible yarns are woven together into a smooth base fabric, the needled fibrous batt layer may be thin, while still providing sufficient cover to bridge over the base fabric weave.

In certain cases, for example in plain press operation on heavy papers, it is necessary that the incompressible base fabric be made thick, so that it will possess a high void volume able to accommodate large quantities of sheet water. Such thick incompressible base fabrics have been made in the past by using large yarns in a single layer fabric, by using multiple yarn layers in a complex weave, or by using more than one base fabric in the same felt.

When incompressible base fabrics are made thick through the use of large incompressible yarns, such coarse yarns tend to impart an objectionable and in some cases, an unacceptable mark to the paper sheet. If more batt is applied in an effort to erase the mark, the point may be reached where the felt is rendered useless in that it no longer can be dewatered by conventional vacuum means.

Yet, such fabrics offer the advantage that they can be woven rapidly, owing to the fact that relatively few yarns are needed to construct a thick, high void volume base fabric from coarse yarns.

When a thick incompressible base fabric is needed which will not impart an objectionable mark to the sheet, it is presently common practice to weave a multi-layered fabric using relatively small incompressible yarns stacked one above the other in either or both directions of the weave. This results in a smooth thick base fabric, but at the expense of increased fabrication costs to make the finer multi-layered fabric. More time is needed to weave the smaller closely spaced yarns into the multi-layered base fabric. Furthermore, yarns stacked above each other in such weaves known as duplex and triplex types may tend to move out of their original spatial relationship and into a common plane through partial collapse of the stacked weave during operation on the machine.

Another present-day alternative method of achieving thick incompressible base structures is to combine two fabrics, one being superimposed over the other in a single needled papermakers felt. Obviously, the expense of this method of achieving a thick incompressible base fabric must be about double the cost of using a single base fabric in the felt.

In all of these current incompressible base fabric structures, fluid permeability and void volume are achieved by interlacing nonpermeable incompressible yarns together to create void spaces in the fabric which are external to the imcompressible yarns. The incompressible yarns themselves, being comprised of monofilaments, twisted monofilaments, resin filled multifilament yarns, or the like, are not fluid permeable nor do they contain

internal void spaces. Present incompressible woven base fabrics must be woven in an open weave arrangement, i.e., with readily observable spaces left between adjacent yarns to achieve permeability and void volume. State of the art incompressible base fabric yarns themselves possess virtually no internal fluid passageways or void space.

Although paper machine dryer fabrics must possess sufficient air permeability to allow for venting of evaporated sheet moisture, excessive air flow must be avoided because of the danger of sheet breaking, particularly at high operating speeds or where the sheet is still fragile due to high moisture content. Since dryer fabrics must operate over prolonged periods of time in hostile environments, while still preserving sufficient permeability to satisfy drying requirements, it has been found advantageous to utilize incompressible yarns in their construction.

It is known that dryer fabrics tend to accumulate debris from the paper sheet during operation on the paper machine. With time, a progressive fillup takes place, particularly at fabric interstices. This fillup reduces permeability and can lead to premature failure and removal of the fabric. Often, monofilament yarns are used as the preferred incompressible dryer fabric yarn, not only because of their outstanding resistance to deformation, but also because such yarns, having smooth outside surfaces, tend to resist contamination better than other types of yarns.

Dryer fabrics contribute to paper machine speed and efficiency by performing several useful functions, one of which is to press the west paper sheet against the hot surface of the drying cans, thereby facilitating heat transfer to the sheet and speeding up the drying process. For maximum heat transfer, the dryer fabric would press

uniformly against the sheet, while still permitting ready egress of moisture laden air or steam. For maximum sheet contact against the can, dryer fabrics should possess numerous closely spaced sheet contact points, with fluid-permeable passageways therebetween.

State of the art dryer fabrics are limited in the extent to which they can achieve intimate sheet contact, controlled air permeability, and resistance to fillup, using current fabrication materials and techniques. For instance, when dryer fabrics are tightly woven, with closely spaced yarns, pressure uniformity against the paper sheet is improved, but at the expense of reduced air permeability and accelerated filling up of the small fabric interstices. On the other hand, when dryer fabrics are made with large spaces between yarns, porosity is improved, along with reduced fillup tendency; however, pressure uniformity against the paper sheet is adversly affected owing to the large gap between adjacent yarns.

It is a principal object of the patent invention to effect important savings in the manufacture of papermaker's fabrics.

It is another object of this invention to provide incompressible fluid-permeable open mesh yarns which contain substantial internal void volume for use in papermaker's forming fabrics, felts, and dryer fabrics.

It is another object of this invention to provide a forming fabric suitable for fine paper production that contains substantially fewer yarns per square inch than is presently required using conventional technology.

It is still another object of this invention to provide thick incompressible felt base fabrics that are economical to manufacture and will not mark the paper sheet when

covered with nonwoven fibrous batting material.

It is still another object of this invention to provide a base fabric for a needled papermaker's felt which contains a substantial portion of its total void volume within the internal circumference of novel incompressible open mesh yarns.

It is yet a further object of this invention to provide a dryer fabric with high resistance to fillup, sufficient permeability, and a smooth surface, which dryer fabric possesses numerous closely spaced contact points with the paper sheet.

In accordance with the invention, incompressible open mesh yarns are incorporated into forming fabrics, dryer fabrics, and press felts. In the case of open mesh tubular materials, a separate yarn insert may be included as a design alternative.

The term "open mesh yarns" as used herein means yarns comprised of one or more incompressible component strands that are interlaced together by a process such as weaving, knitting, crocheting, braiding, knit-braiding or the like to form a continuous incompressible yarn assembly. This yarn assembly is characterized by frequent structural interlacings, crossovers, or loops along the length of the yarn, and void spaces located between adjacent interlaced strands, forming interconnected fluid passageways therebetween.

When such open mesh yarns are incorporated into papermaker's forming fabrics, felts or dryer fabrics, advantages in manufacturing economy and performance result. Additional objects and advantages of this invention, together with a better understanding thereof, may be had by referring to the following description, together with the accompanying drawings.

Fig. 1 is a side perspective view of an open mesh yarn of this invention.

Fig. 2 is a side perspective view of an open mesh yarn of this invention having a cabled monofilament yarn insert.

Fig. 3 is a top view of a fabric of this invention having machine direction open mesh yarns.

Fig. 4 is a top view of a fabric of this invention having cross-machine direction open mesh yarns.

Fig. 5 is a cross-sectional view of the fabric of Fig. 4 taken along the line A-A' of Fig. 4.

Fig. 6 is a cross-sectional view of the fabric of Fig. 4 taken along the line B-B' of Fig. 4.

Fig. 7 is the same cross-sectional view as Fig. 5, except that the fabric is covered with batt on both top and bottom surfaces.

Fig. 8 is the same cross-sectional view as Fig. 6, except that the fabric is covered with batt on both top and bottom surfaces.

Special incompressible porous open mesh yarn structures can be incorporated into papermaker's forming fabrics, dryer fabrics, and press felts to achieve novel fabric constructions. These open mesh yarn structures contain void spaces which remain permeable to fluid flow, even when said open mesh yarns are incorporated in fabrics and subjected to continuous operation on papermaking forming, pressing and drying sections.

These open mesh yarn structures comprise one or more incompressible yarn strands interlaced together by the process of knitting, crocheting, braiding, knit-braiding,

weaving, or the like, to produce narrow tubular or flat open mesh yarns. In the preferred case, the strand or strands comprising the open mesh yarn are composed of monofilament synthetic polymers such as nylon, polyester, or other incompressible polymer materials. However, multifilaments or spun yarns may also be used, provided that such yarns are rendered incompressible by any process known in the art, such as resin impregnation and curing.

Use of the term "incompressible", when referring to yarns of this invention, means yarns which are resistant to deformation under the pressures they are subjected to in operation on the paper machine. Monofilament yarns made of non-elastic polymer materials such as polyester, nylon, or polycarbonate, are considered to be incompressible yarns by this definition; whereas, yarns made from these same polymer materials in the form of continuous multifilament or spun yarns may be expected to undergo substantial deformation in use on the paper machine and are therefore considered to be compressible yarns.

Other fabrication methods may also be used to prepare open mesh yarns for use in papermaker's fabrics. For example, plastic net extrusion equipment could be adapted to make flat or tubular narrow open mesh constructions for insertion into papermaker's felts, forming fabrics, and dryer fabrics. Preferably, the extruded materials would be fused together at mesh cross-over points, and would still retain sufficient pliability for weaving into fabrics.

If incompressible open mesh yarns are to be used in a papermaker's fabric comprising interwoven weft and warp systems, then, in every weave repeat, at least one yarn in one of said systems should comprise an incompressible open mesh yarn.

Open mesh yarns can be used advantageously as weft or warp yarns in forming fabrics. One purpose of incorporating open mesh yarns in forming fabrics is to permit substitution of fewer large mesh yarns in place of many fine conventional yarns to effect important manufacturing savings. For example, a fine open mesh yarn measuring 100 mils in width and having a self-contained interconnected fine mesh network of ten strands from side-to-side could replace ten conventional fine yarns at a substantial savings in loom production time.

In the case of layered or double cloth forming fabrics where two systems of yarn are used in warp and/or weft, the incompressible open mesh yarn of this invention may be used advantageously in the sheet contact layer. Because forming fabrics are subject to little if any sheet side surface pressure during use, it would be preferable to carry out special surface finishing steps such as compressing, heat setting, fusion bonding, or chemical treatment to preform the sheet contact layer of the fabric into a smooth continuous open mesh surface for minimum sheet marking.

Where fine forming fabrics are required, added stretch resistance can be achieved through the use of an insert located in the center of a tubular open-mesh yarn. Such insert may be made, for example, from high tenacity polyester monofilament or from an aramid multifilament yarn, such as Kevlar 29™, a product of Dupont Corporation.

Open mesh yarns can be used advantageously as loom weft or loom warp in press felts. Owing to the relatively fine internal pore structure of the open mesh yarn, wide yarns could be woven to effectuate significant savings in fabrication and the finished felt surface would still produce little weave knuckle mark by virtue of the network of fine interlaced and interconnected strands

within the open mesh yarn. Furthermore, such incompressible open mesh yarns serve to provide substantial void space within the felt due to their resistance to deformation under pressure.

Not only can incompressible open mesh yarns be used advantageously as loom filling or loom warp in the base fabric of a press felt, but open mesh yarns can also be used advantageously between a coarse yarn base structure and a fine batt fiber capping layer of a press felt. The open mesh yarn would form a much more uniform batt than could be obtained with coarse fibers using presently available nonwoven random batt forming methods. In addition, the adherence of the coarse mesh layer to the base fabric substrate would probably be better than could be obtained by needling alone.

Open mesh yarns can also be used advantageously as warp yarns in fillingless felts of the type disclosed in U.S. 3,392,079, the teachings of which are incorporated herein by reference. In these felts, a loosely cohesive base fabric is formed from a plurality of spaced fuzzy or spuriously fibered warp yarns and, in place of weft or filling yarns, fibers oriented substantially at right angles to the warp yarns are needled to one or both sides of the base fabric.

Insertion of a polyurethane or rubber cut strand or monofilament in the core position of a porous open mesh yarn would provide further benefits to felt performance by acting as a shock absorber, thereby reducing press vibration on heavily loaded positions.

Open mesh yarns can also be used advantageously as weft or warp yarns in dryer fabrics. Papermaker's dryer fabrics, having controlled permeability over a wide range,

may be fabricated from open mesh yarns using many less weave interlacings than would be necessary using conventional yarns. Nevertheless, such dryer fabrics would possess a high surface contact area, by virtue of the many individual open mesh yarn elements which would be brought into contact with the sheet.

Where lowered permeability is desired in an open mesh monofilament dryer fabric, a spun yarn insert could be added to the open mesh yarn. This insert could reduce air permeability without adversely affecting fill-up, since the insert would be isolated from sheet contact by the open mesh monofilament sheath. If the insert possessed springiness, it could further enhance open mesh yarn contact with the paper, thus aiding drying rate.

This invention is further illustrated by the following non-limited examples.

EXAMPLE 1

The incompressible open mesh yarn 1, of Fig. 1, was made on a four needle Model 2NBA knit braiding machine manufactured by the Lamb Knitting Machine Corporation Chicopee, Massachusetts. This open mesh yarn 1 was comprised of four 1370 denier polyester monofilament strands 2 of 0.015 inches diameter. The individual monofilaments 2 were interlaced in what is known as the alternate crossover pattern,with six courses per linear inch. The open mesh yarn so formed was 22,050 denier and weighed approximately sixteen times as much as a single monofilament component strand, the mesh yarn being the product of four strands each following a different circuitous path about the other strands as it interlaced into the structure. When compressive forces are applied to yarns of this type, the monofilament member strands are readily brought into initial pressure contact

with each other, whereupon further compression of the yarn is restricted and opposed by the multiplicity of monofilament interlacings so that complete compaction requires pressure concentrations which are beyond those normally encountered on paper machines.

EXAMPLE 2

The incompressible open mesh yarn 4, of Fig. 2 was made on a six needle knit-braiding machine similar to that used in Example 1. In this case, six 0.010 inch diameter polyester monofilament yarns formed a tubular open mesh structure which contained a nylon resin treated continuous filament yarn insert 5 of 0.032 inch diameter. Open mesh yarns containing inserts which are stretch resistant are particularly well suited for use in the machine direction of paper machine forming fabrics, felts, and dryer fabrics.

EXAMPLE 3

The press felt base fabric 6, of Fig. 3 was woven in a broken twill weave with eight ends per inch of 840 denier nylon multifilament yarn 7 in the cross machine direction and ten yarns per inch of 18,000 denier tubular knit-braid incompressible open mesh yarn 8 in the machine direction. The open mesh yarn was comprised of six polyester monofilament strands 9 of 0.010 inch diameter with an insert 10 of sic ply 0.008 inch diameter cabled polyester monofilament yarn. The insert is depicted in Fig. 3 as if the mesh yarn sheath had been removed at the edge of the photograph. The cabled monofilament yarn insert provides additional stretch resistance in the tension or machine direction of the fabric. Both plied and cabled monofilament yarns can be used beneficially as open mesh yarn inserts.

In this base fabric, practically no visible void space existed between adjacent open mesh yarns. Yet, due to the

presence of substantial interconnected void spaces within the open mesh yarns themselves, this base fabric possessed high void volume and an air permeability in excess of 700 cubic feet/minute/square foot measured at 0.5 inch water pressure differential. Also, the inclusion of very large incompressible open mesh yarns did not result in the usual pronounced knuckle pattern at yarn crossover points, due to the fine internal open mesh yarn network of interlacings. The open mesh yarns contain a plurability of spaced apart individual component strands, which effectively spread the compression load over a multitude of strand crossovers within the open mesh yarn itself.

Fabrics of this type are well suited for the purpose of mist elimination, where large surface areas and high permeability are needed to obtain adequate flow rates at high liquid entrainment efficiencies.

EXAMPLE 4

With reference to Figs. 4-8, a felt base fabric 11 was made using small 840 denier nylon continuous filament warp yarns 13, nylon monofilament weft yarns with .010 inch diameters 14 and 14' and large 14,500 denier polyester open mesh stuffer yarns 12.

The open mesh stuffer yarn 12 was laid in the fabric without actually interlacing, weaving being accomplished solely through interlacing of the fine multifilament warp yarns 13 with the nylon monofilament filling yarns 14 and 14'. Filling yarn 14 weaved above all open mesh stuffer yarns 12, interlacing with warp yarns 13; whereas filling yarn 14' maintained a constant path below all of the mesh yarns 12 present in the fabric, while interlacing with warp yarns 13 as they alternately passed from top to bottom of the fabric.

As can be most clearly seen in Figs. 5 and 6, the laid in open mesh stuffer yarns 12 contribute substantially to the thickness and void volume of the felt base fabric, yet they do not create pronounced irregularities in the fabric at yarn crossovers due to the fact that they are comprised of a multiplicity of smaller monofilament members, and also, because in this construction, the open mesh stuffer yarns maintain a central position in the fabric.

As seen in Figs. 7 and 8, a batting 15 of 15 denier nylon fiber was needled to the top and bottom surfaces of the base fabric to complete the felt.

While this invention has been described with reference to its preferred embodiment, other embodiments can achieve the same result. Variations and modifications of the present invention, will be obvious to those skilled in the art and it is intended to cover in the appended claims all such modifications and equivalents as fall within the spirit and scope of this invention.

CLAIMS

1. A papermaker's fabric wherein said fabric contains incompressible open mesh yarns.

2. A base fabric of a papermaker's felt wherein said base fabric contains incompressible open mesh yarns.

3. A papermaker's fabric comprising interwoven weft and warp yarn systems and stuffer yarns, wherein said stuffer yarns comprise incompressible open mesh yarns.

4. A papermaker's fabric comprising interwoven weft and warp yarn systems, wherein in every weave repeat, at least one yarn in one of said yarn systems comprises an incompressible open mesh yarn.

5. A fillingless papermaker's felt, wherein said felt contains incompressible open mesh yarns.

6. The fabric of claims 1, 2, 3, 4 or 5 wherein the incompressible open-mesh yarns are prepared from one or more individual yarn strands by the process of knitting, crocheting, braiding, knit-braiding, or weaving.

7. The fabric of claims 1, 2, 3, 4 or 5 wherein the open mesh yarns are prepared by the process of plastic extrusion.

8. The fabric of claims 1, 2, 3, 4 or 5 wherein the one or more individual yarn strands which make up each open mesh yarn comprise synthetic monofilaments.

9. The fabric of claim 6 wherein the one or more individual yarn strands which make up each open mesh yarn comprise synthetic monofilaments.

10. The fabric of claim 8 wherein said synthetic

monofilament is a polyester monofilament.

11. The fabric of claim 9 wherein said synthetic monofilament is a polyester monofilament.

12. The fabric of claim 8 wherein said synthetic monofilament is a nylon monofilament.

13. The fabric of claim 9 wherein said synthetic monofilament is a nylon monofilament.

14. The fabric of claims 1, 2, 3, 4 or 5 wherein the one or more individual yarn strands which make up each open mesh yarn comprise resin-impregnated multifilaments.

15. The fabric of claim 6 wherein the one or more individual yarn strands which make up each open mesh yarn comprise resin-impregnated multifilaments.

16. The fabric of claims 1, 2, 3, 4 or 5 wherein said open mesh yarns are narrow tubular.

17. The fabric of claim 16 wherein the narrow tubular open mesh yarn has an insert.

18. The fabric of claim 17 wherein said insert comprises a synthetic monofilament.

19. The fabric of claim 17 wherein the insert comprises synthetic plied monofilaments.

20. The fabric of claim 17 wherein the insert comprises synthetic cables monofilaments.

21. The fabric of claims 18, 19 or 20 wherein said synthetic monofilaments comprise polyester monofilaments.

22. The fabric of claims 18, 19 or 20, wherein said synthetic monofilaments comprise polyurethane monofilaments.

23. The fabric of claim 17 wherein said insert comprises spun yarn.

24. The fabric of claim 17 wherein said insert comprises an aramid multifilament.

25. The fabric of claim 6 wherein said open mesh yarns are narrow tubular.

26. The fabric of claim 25 wherein the narrow tubular open mesh yarn has an insert.

27. The fabric of claim 26 wherein said insert comprises a synthetic monofilament.

28. The fabric of claim 26 wherein the insert comprises synthetic plied monofilaments.

29. The fabric of claim 26 wherein the insert comprises synthetic cabled monofilaments.

30. The fabric of claims 27, 28 or 29 wherein said synthetic monofilaments comprise polyester monofilaments.

31. The fabric of claims 27, 28 or 29 wherein said synthetic monofilaments comprise polyurethane monofilaments.

32. The fabric of claim 26 wherein said insert comprises spun yarn.

33. The fabric of claim 26 wherein said insert comprises an aramid multifilament.

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FIG. 1

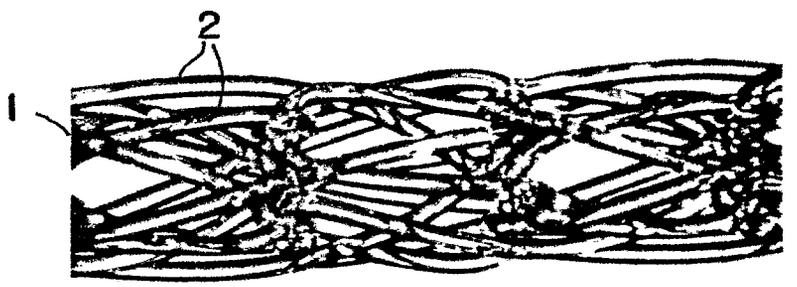

FIG. 2

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FIG. 3

FIG. 4

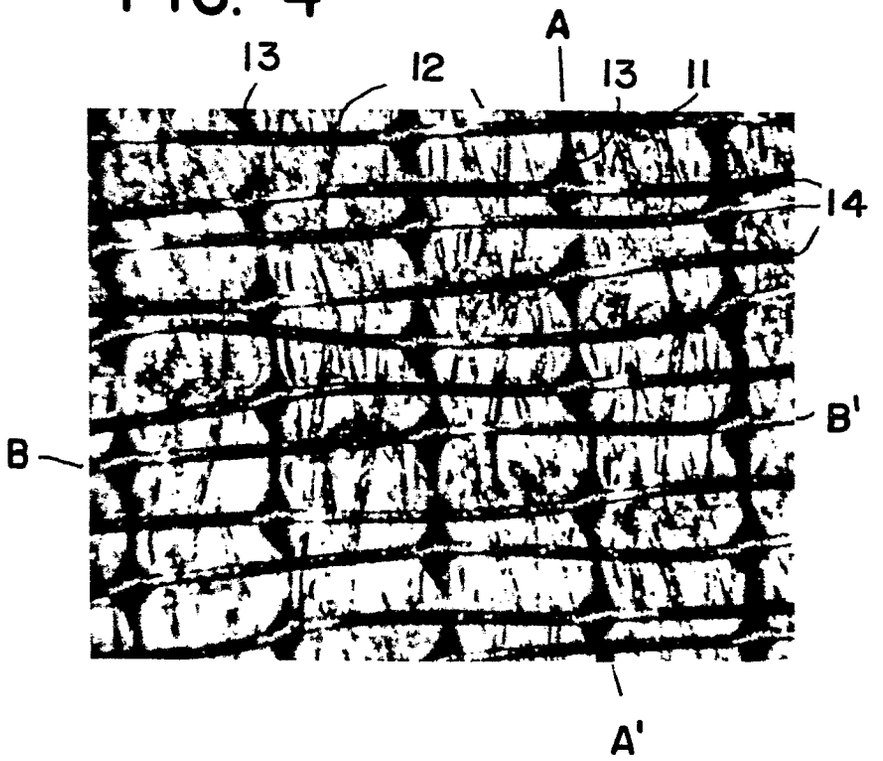

FIG. 5

FIG. 6

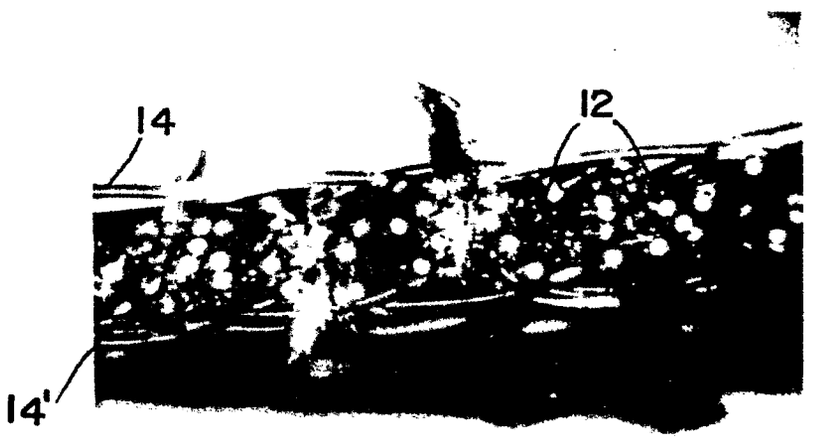

FIG. 7

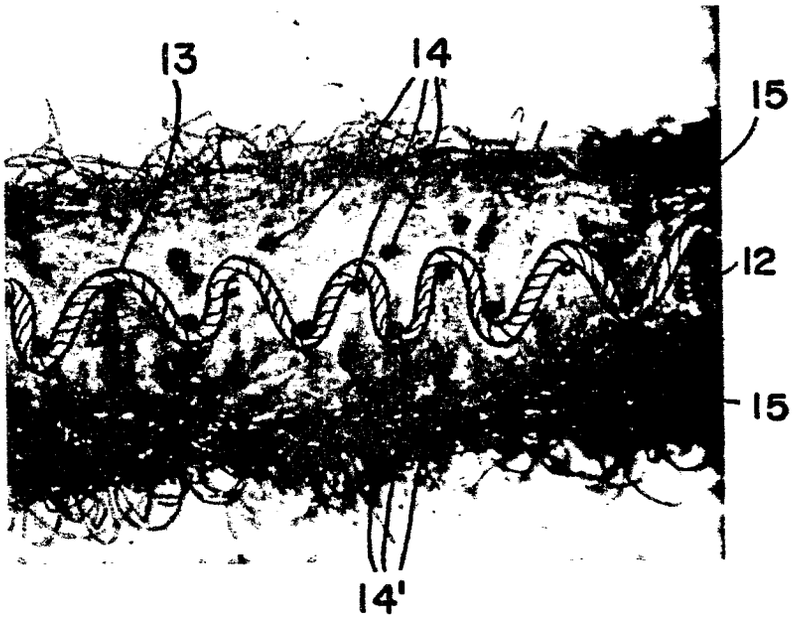

FIG. 8