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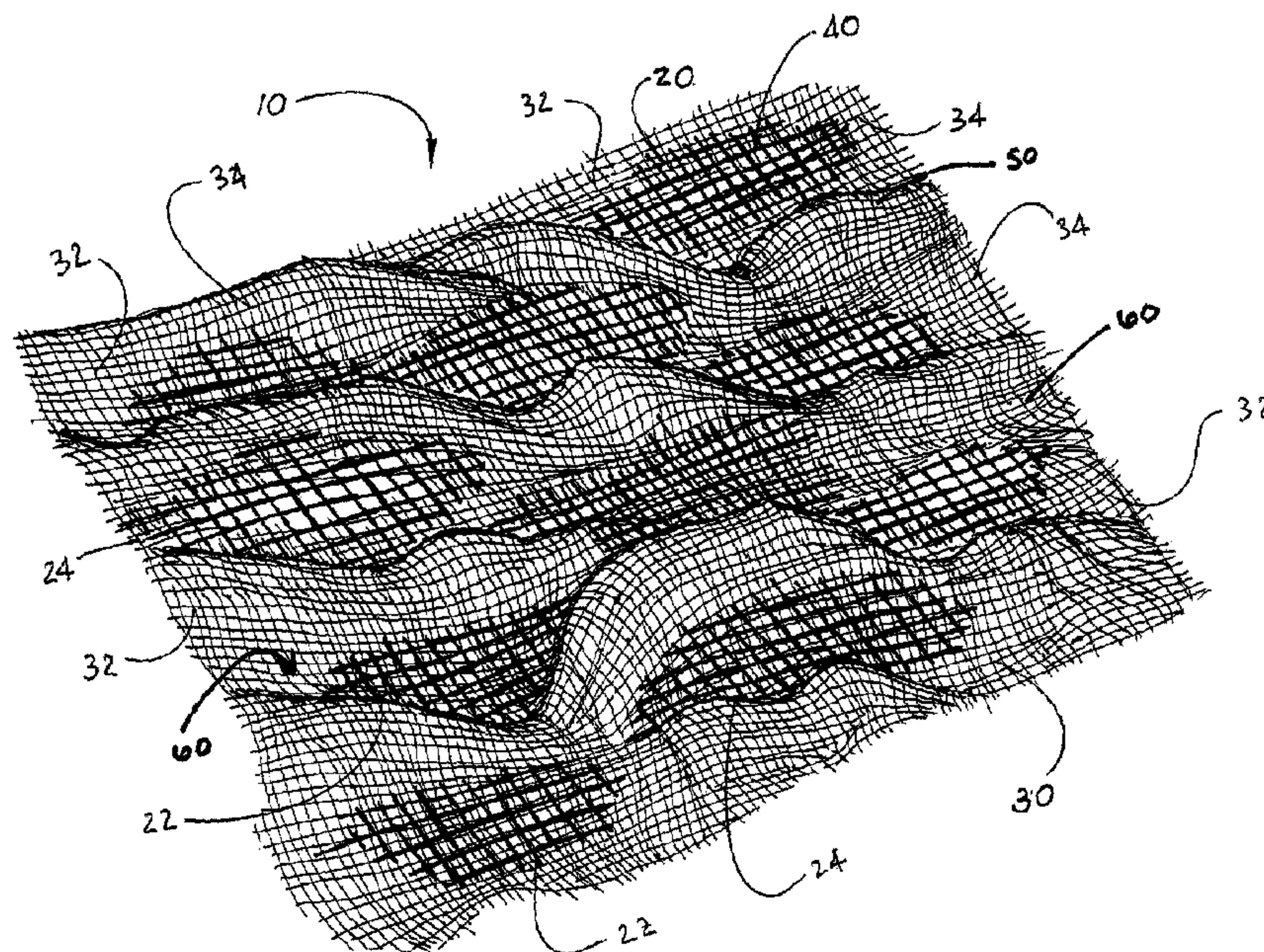
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(54) Titre : NATTE DE CONTROLE DE L'EROSION POUR RENFORCEMENT DE GAZON DE PLACAGE

(54) Title: TURF REINFORCEMENT EROSION CONTROL MAT



(57) Abrégé/Abstract:

A bi-layer, woven geotextile fabric has interwoven first and second layers. The first layer is over and under woven through the second layer in a pre-determined pattern so that the first layer has portions which face a first side of the second layer and portions which face a second side of the second layer. Monofilaments in the warp direction of the first layer have a predetermined differential heat shrinkage characteristic that is greater than the monofilaments in the warp direction of the second layer. Closed cells defined by the pattern of the over and under weave are disposed on the first and second sides of the second layer. Shrinkage of the monofilaments in the warp direction of the first layer provide for a separation of a portion of the second layer from the first layer at the cells.

1 ABSTRACT

2 A bi-layer, woven geotextile fabric has interwoven first and second layers. The first layer
3 is over and under woven through the second layer in a pre-determined pattern so that the first
4 layer has portions which face a first side of the second layer and portions which face a second
5 side of the second layer. Monofilaments in the warp direction of the first layer have a pre-
6 determined differential heat shrinkage characteristic that is greater than the monofilaments in
7 the warp direction of the second layer. Closed cells defined by the pattern of the over and
8 under weave are disposed on the first and second sides of the second layer. Shrinkage of the
9 monofilaments in the warp direction of the first layer provide for a separation of a portion of the
10 second layer from the first layer at the cells.

TURF REINFORCEMENT EROSION CONTROL MAT

TECHNICAL FIELD OF THE INVENTION

The present invention relates generally to woven geotextile fabrics. More specifically, the present invention is related to bi-layer woven geotextile fabrics which inhibit or reduce soil erosion and promote seed germination and root stabilization in the soil.

BACKGROUND OF THE INVENTION

During the construction of structures, buildings, bridges, roadways, airfields, dikes, dams, culverts, and the like, it is common to grade the landscape, disturb the surrounding soil, and remove adjacent vegetation to leave bare soil. It is well known that water runoff and wind cause bare soil to erode. Soil erosion is problematic from soil stabilization, environmental contamination, and cost perspectives. These problems are exacerbated when non-stabilized soil is on steepened slopes and channels where the speed of water runoff is accelerated. Typically, crushed stone, rip-rap, mulch, straw, and the like are placed on non-stabilized soil to reduce or prevent soil erosion. However, this solution does not always provide satisfactory results, often requires routine maintenance, and can be expensive.

It is well known that vegetation ground cover is excellent for stabilizing soil and preventing erosion. However, it is difficult to promote plant growth among crushed stone and rip-rap. Even when an occasional plant does grow among the stone or rocks, there is insufficient plant density to be effective in retaining the soil.

Certain geotextile fabrics have been employed to retain soil. However, a similar problem exists as with stone. That is, it is difficult to establish sufficient plant density to create a stabilizing interlocking plant root system for long-lasting soil stabilization.

Accordingly, there is a need for a woven geotextile fabric which can inhibit or eliminate soil erosion on non-stabilized soil and promote seed germination and root stabilization, even on steepened slopes and channels. It is to solving this problem the present invention is directed.

SUMMARY OF THE INVENTION

In accordance with the present invention, a bi-layer, woven geotextile fabric which can be employed as a turf reinforcement soil erosion control mat is described herein. The fabric has interwoven first and second layers. The first layer comprises monofilaments respectively woven

1 in the warp and fill directions and has first and second sides. Similarly, the second layer
2 comprises monofilaments respectively woven in the warp and fill directions. The second layer is
3 over and under woven through the first layer in a pre-determined pattern so that the second
4 layer has portions which face the first side of the first layer and portions which face the second
5 side of the first layer. Monofilaments in the warp direction of the first layer have a pre-
6 determined differential heat shrinkage characteristic that is greater than the monofilaments in
7 the warp direction of the second layer. Further, the fabric has cells disposed on the first and
8 second sides of the first layer. The cells are respectively defined by the pattern of the over and
9 under weave of the second layer, and each cell defines a permeable, enclosed cavity.

10 Upon being exposed to sufficient heat and/or temperature, the monofilaments in the
11 warp direction of the first layer shrink to a greater degree than the monofilaments of the second
12 layer due to the greater differential heat shrinkage characteristic. Such shrinkage of the
13 monofilaments in the warp direction of the first layer provides for a separation of a portion of the
14 second layer from the first layer at the cells.

15 Alternatively, the warp and fill monofilaments of the first layer can comprise the same
16 material. Further, the warp and fill monofilaments of the second layer can comprise the same
17 material.

18 In another aspect of the present invention, the bi-layer, woven geotextile fabric
19 comprises interwoven first and second layers. First and second layers comprise monofilaments
20 respectively woven in warp and fill directions. The first layer has first and second sides.
21 Further, the second layer is over and under woven through the first layer in a pre-determined
22 pattern so that the second layer has portions which face the first side of the first layer and
23 portions which face the second side of the first layer. Monofilaments in the warp and fill
24 directions of the first layer have a pre-determined differential heat shrinkage characteristic
25 greater than the respective monofilaments in the warp and fill directions of the second layer.
26 Additionally, cells are disposed on the first and second sides of the first layer and are defined by
27 the pattern of the over and under weave of the second layer. Each cell defines a permeable,
28 enclosed cavity.

29 Still, in another aspect of the present invention, the bi-layer, woven geotextile fabric
30 comprises interwoven first and second layers. Each layer has monofilaments respectively
31 woven in the warp and fill directions. The first layer has first and second sides. The second

1 layer is over and under woven through the first layer in a pre-determined pattern so that the
2 second layer has portions which face the first side of the first layer and portions which face the
3 second side of the first layer. Cells are disposed on the first and second sides of the first layer
4 and are respectively defined by the pattern of the over and under weave of the second layer.
5 Each cell defines a permeable, enclosed cavity and has a portion of the first layer that is spaced
6 apart from a portion of the second layer.

7 Yet, in another aspect of the present invention, the bi-layer, woven geotextile fabric
8 comprises interwoven first and second layers. Each layer has monofilaments respectively
9 woven in the warp and fill directions. The monofilaments of the first layer comprise
10 polyethylene. Polypropylene monofilaments comprise the second layer. The second layer is
11 over and under woven through the first layer in a pre-determined pattern so that the second
12 layer has portions which face the first side of the first layer and portions which face the second
13 side of the first layer. Cells are disposed on the first and second sides of the first layer and are
14 defined respectively by the pattern of the over and under weave of the second layer. Each cell
15 defines a permeable, enclosed cavity.

16 Upon being exposed to sufficient heat and/or temperature, the monofilaments in the
17 warp direction of the first layer shrink to a greater degree than the monofilaments of the second
18 layer due to the greater differential heat shrinkage characteristic. Such shrinkage of the
19 monofilaments in the warp direction of the first layer provides for a separation of a portion of the
20 second layer from the first layer at the cells.

21 It is to be understood that the phraseology and terminology employed herein are for the
22 purpose of description and should not be regarded as limiting. As such, those skilled in the art
23 will appreciate that the conception, upon which this disclosure is based, may readily be utilized
24 as a basis for the designing of other structures, methods, and systems for carrying out the
25 present invention.

26 Other advantages and capabilities of the present invention will become apparent from
27 the following description taken in conjunction with the accompanying drawings showing the
28 elements and the various aspects of the present invention.

29
30 **BRIEF DESCRIPTION OF THE OF DRAWINGS**

1 The disclosure below makes reference to the annexed drawings wherein:

2 Figure 1 is a perspective view of a turf reinforcement erosion control mat in accordance
3 with the present invention.

4 Figure 2 is an illustration in perspective view of a pre-tentered turf reinforcement erosion
5 control mat in accordance with the present invention.

6 Figure 3 is a cross-sectional view of the turf reinforcement erosion control mat of Figures
7 1 and 2 illustrating an over and under weave.

8 Figure 4 is another cross-sectional view of the turf reinforcement erosion control mat of
9 Figures 1 and 2 illustrating the over and under weave.

10 Figure 5 is another illustration in perspective view of a tented turf reinforcement
11 erosion control mat in accordance with the present invention.

12 Figure 6 is a perspective view of the turf reinforcement erosion control mat in
13 accordance with the present invention employing a honeycomb pattern.

14 **DETAILED DESCRIPTION OF THE INVENTION**

15 A turf reinforcement erosion control mat (TREC) in accordance with the present
16 invention, also referred to herein as a bi-layer geotextile fabric, can be employed to reduce or
17 eliminate soil erosion. Further, the TREC can be employed to promote seed germination, root
18 stabilization, and vegetative reinforcement.

19 The TREC is a bi-layer, woven geotextile fabric which has interwoven first and second
20 layers. The first layer comprises monofilaments or yarns respectively in the warp direction
21 woven with yarns in the weft or fill direction. Additionally, the first layer has first and second
22 sides. Similarly, the second layer comprises monofilaments respectively woven in the fill
23 direction and has first and second sides. The second layer is over and under woven through
24 the first layer in a pre-determined pattern so that the second layer has portions which face the
25 first side of the first layer and portions which face the second side of the first layer.

26 Monofilaments in the warp direction of the first layer have a pre-determined differential heat
27 shrinkage characteristic that is greater than the monofilaments in the warp direction of the
28 second layer. Further, the fabric has cells disposed on the first and second sides of the first

1 layer. The cells are respectively defined by the pattern of the over and under weave of the
2 second layer, and each cell defines a permeable, enclosed cavity.

3 Monofilaments which have a greater differential heat shrinkage characteristic are
4 referred to as shrink yarns. Shrink yarns have greater shrinkage than non-shrink yarns when
5 exposed to the same heat and/or temperature conditions. It is understood that non-shrink yarns
6 can nominally shrink. However, such shrinkage is relatively insignificant as compared to the
7 degree or amount of shrinkage of the shrink yarns at like heat and/or temperature conditions. In
8 other words, the shrink yarns shrink more than the non-shrink yarns under the same heat and/or
9 temperature conditions. Accordingly, upon being exposed to a sufficient duration of heating at a
10 sufficient temperature, the monofilaments in the warp direction of the first layer shrink to a
11 greater degree than the monofilaments in the warp direction of the second layer. This
12 difference in shrinkage is due to the greater differential heat shrinkage characteristic of the
13 monofilaments in the warp direction of the first layer with respect to the monofilaments in the
14 warp direction of the second layer. Such shrinkage of the monofilaments in the warp direction
15 of the first layer provides for a separation of a portion of the second layer from the first layer at
16 the cells.

17 Alternatively, the warp and fill monofilaments of the first layer can comprise the same
18 material. Alternatively, both the warp and fill monofilaments of the first layer can be shrink
19 yarns, even though such shrink yarns can comprise different polymers. Further, the warp and
20 fill monofilaments of the second layer can be the same or different non-shrink yarns.

21 In another aspect of the present invention, the bi-layer, woven geotextile fabric
22 comprises interwoven first and second layers. Both layers comprise monofilaments respectively
23 woven in warp and fill directions. The first layer has first and second sides. Further, the second
24 layer is over and under woven through the first layer in a pre-determined pattern so that the
25 second layer has portions which face the first side of the first layer and portions which face the
26 second side of the first layer. Monofilaments in the warp and fill directions of the first layer have
27 a pre-determined differential heat shrinkage characteristic greater than the respective
28 monofilaments in the warp and fill directions of the second layer. Additionally, cells are
29 disposed on the first and second sides of the first layer and are defined by the pattern of the
30 over and under weave of the second layer. Each cell defines a permeable, enclosed cavity.

1 Still, in another aspect of the present invention, the bi-layer, woven geotextile fabric
2 comprises interwoven first and second layers. Each layer has monofilaments respectively
3 woven in the warp and fill directions. The first layer has first and second sides. The second
4 layer is over and under woven through the first layer in a pre-determined pattern so that the
5 second layer has portions which face the first side of the first layer and portions which face the
6 second side of the first layer. Cells are disposed on the first and second sides of the first layer
7 and are respectively defined by the pattern of the over and under weave of the second layer.
8 Each cell defines an enclosed cavity and has a portion of the first layer that is spaced apart from
9 a portion of the second layer.

10 Yet, in another aspect of the present invention, the bi-layer, woven geotextile fabric
11 comprises interwoven first and second layers. Each layer has monofilaments respectively
12 woven in the warp and fill directions. The monofilaments of the first layer comprise
13 polyethylene. Polypropylene monofilaments comprise the second layer. The second layer is
14 over and under woven through the first layer in a pre-determined pattern so that the second
15 layer has portions which face the first side of the first layer and portions which face the second
16 side of the first layer. Cells are disposed on the first and second sides of the first layer and are
17 defined respectively by the pattern of the over and under weave of the second layer. Each cell
18 defines a permeable, enclosed cavity.

19 Upon being exposed to sufficient heat and/or temperature conditions, the polyethylene
20 monofilaments in the warp direction of the first layer shrink to a greater degree than the
21 polypropylene monofilaments of the second layer due to the greater differential heat shrinkage
22 characteristic of polyethylene. Such shrinkage of the monofilaments in the warp direction of the
23 first layer provides for a separation of a portion of the second layer from the first layer at the
24 cells.

25 For a fuller understanding of this disclosure and the invention described therein,
26 reference should be made to the above and following detailed description taken in connection
27 with the accompanying figures. When reference is made to the figures, like reference numerals
28 designate corresponding parts throughout the several figures. With reference to Figure 1, the
29 bi-layer, woven geotextile fabric 10 includes a first layer 20 and a second layer 30. First layer
30 20 comprises warp yarn 22 that is woven together with weft or fill yarn 24. Similarly, the second
31 layer 30 comprises warp yarn 32 that is woven together with fill yarn 34 and has a first side 36

1 and a second side 38. Moreover, first layer 20 is over and under woven through the second
2 layer 30.

3 As discussed above, warp yarn 22 is shrink yarn. In another aspect of the invention, fill
4 yarn 24 is shrink yarn. Still, in another aspect, the warp and fill yarns 22, 24 can be the same or
5 different shrink yarn. The non-shrink warp and fill yarns 32, 34 of the second layer 30 can be
6 the same or different. The independent shrink and non-skrinker yarn systems are woven
7 together so that the positioning of the shrink yarns dictate the properties of the finished fabric
8 such as: thickness, bi-layer and multi-axial root support, opening sizes, strength, weight,
9 stiffness, and width.

10 As known in the art, a woven fabric has two principle directions, one being the warp
11 direction and the other being the weft direction. The weft direction is also referred to as the fill
12 direction. The warp direction is the length wise, or machine direction of the fabric. The fill or
13 weft direction is the direction across the fabric, from edge to edge, or the direction traversing the
14 width of the weaving machine. Thus, the warp and fill directions are generally perpendicular to
15 each other. The set of yams, threads, or monofilaments running in each direction are referred
16 to as the warp yarns and the fill yarns, respectively.

17 A woven fabric can be produced with varying densities. This is usually specified in terms
18 of number of the ends per inch in each direction, warp and fill. The higher this value is, the
19 more ends there are per inch and, thus, the fabric density is greater or higher. Although not
20 required, it is beneficial for seed germination and propagation of a root system for the respective
21 fabric densities of the first and second layers to be sufficiently low that adjacent monofilaments
22 in the warp and fill directions do not contact one another. However, it is within the scope of the
23 invention if either or both the first and second layers have a plurality of warp yarns contacting
24 one another and/or a plurality of fill yarns contacting one another. Further, the fabric density of
25 the first layer 20 is between 5 and 30 ends/inch in the warp and fill directions, independently. In
26 another aspect, the fabric density of the first layer 20 in the warp direction is 5, 6, 7, 8, 9, 10, 11,
27 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, or 30 ends/inch. Likewise,
28 in another aspect, the fabric density of the first layer 20 in the fill direction is 5, 6, 7, 8, 9, 10, 11,
29 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, or 30 ends/inch. Similarly,
30 the fabric density of the second layer 30 is between 5 and 40 ends/inch in the warp and fill
31 directions, independently. In another aspect, the fabric density of the second layer 30 is
32 between 10 and 40 ends/inch in the warp and fill directions, independently. Yet, in another

1 aspect, the fabric density of the second layer 30 in the warp direction is 10, 11, 12, 13, 14, 15,
2 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, or 40
3 ends/inch. Likewise, in another aspect, the fabric density of the second layer 30 in the fill
4 direction is 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31,
5 32, 33, 34, 35, 36, 37, 38, 39, or 40 ends/inch.

6 The weave pattern of fabric construction is the pattern in which the warp yarns are
7 interlaced with the fill yarns. A woven fabric is characterized by an interlacing of these yarns.
8 There are many variations of weave patterns commonly employed in the textile industry, and
9 those of ordinary skill in the art are familiar with most of the basic patterns. While it is beyond
10 the scope of the present application to include a disclosure of these multitude of weave
11 patterns, the basic plain, twill, satin, honeycomb weave patterns can be employed with the
12 present invention. However, such patterns are only illustrative, and the invention is not limited
13 to such patterns. It should be understood that those of ordinary skill in the art will readily be
14 able to determine how a given weave pattern could be employed in practicing the present
15 invention in light of the parameters herein disclosed.

16 Plain weave is characterized by a repeating pattern where each warp yarn is woven over
17 one fill yarn and then woven under the next fill yarn, as illustrated in Figures 1-5. As mentioned
18 above, but not required, spacing between warp and fill yarns of the first and second layers,
19 respectively, is maintained to provide sufficient space for vegetation to germinate and grow
20 therethrough.

21 A twill weave, relative to the plain weave, has fewer interlacings in a given area. The
22 twill is a basic type of weave, and there are a multitude of different twill weaves. A twill weave is
23 named by the number of fill yarns which a single warp yarn goes over and then under. For
24 example, in a 2/2 twill weave, a single warp end weaves over two fill yarns and then under two
25 fill yarns. In a 3/1 twill weave, a single warp end weaves over three fill yarns and then under
26 one fill yarn. For fabrics being constructed from the same type and size of yarn, with the same
27 thread or monofilament densities, a twill weave has fewer interlacings per area than a
28 corresponding plain weave fabric.

29 A satin weave, relative to the twill and plain weaves, has fewer interlacings in a given
30 area. It is another basic type of weave from which a wide array of variations can be produced.
31 A satin weave is named by the number of ends on which the weave pattern repeats. For

1 example, a five harness satin weave repeats on five ends and a single warp yarn floats over
2 four fill yarns and goes under one fill yarn. An eight harness satin weave repeats on eight ends
3 and a single warp yarn floats over seven fill yarns and passes under one fill yarn. For fabrics
4 being constructed from the same type of yarns with the same yarn densities, a satin weave has
5 fewer interlacings than either a corresponding plain or twill weave fabric.

6 Three-dimensional weave patterns can also be employed in the present invention.
7 These weave patterns include honeycomb, diamond, double cloth, crepe, and huckaback. For
8 example, a honeycomb weave pattern is disclosed in U.S. Patent No. 5,567,087. The
9 monofilaments employed in the honeycomb pattern layer can be biaxially heat shrinkable. That
10 is, upon being heated, the filament yarns shrink in both directions.

11 The process for making geotextile fabrics is well known in the art. Thus, the weaving
12 process employed can be performed on any conventional textile handling equipment suitable for
13 producing the fabric of the present invention. Further, any of the aforementioned patterns
14 weaves may be employed for either or both the first and second layers.

15 As mentioned above, the first layer 20 is over and under woven through the second layer
16 30, as illustrated in Figures 1-6. That is, a portion of the first layer 20 faces the first side 36 of
17 the second layer 30 and another portion of the first layer 20 faces the second side 38 of the
18 second layer 30. This over and under weave is repeated and offset in the warp and fill
19 directions to create various patterns or blocks on the first and second sides 36, 38 of the second
20 layer 30. The appearance is reminiscent of a "checkerboard". This offset is illustrated in
21 Figures 1, 2, 5, and 6. Figure 2 is a "flat" TREC, that is, the fabric 10 has been woven, but not
22 tentered. Tentered means that the fabric 10 has been subjected to sufficient heat and/or
23 temperature conditions and duration to shrink the shrink yarns. Alternatively stated, the shrink
24 first layer 20 is woven on top of the non-shrink second layer 30 in a block, while the non-shrink
25 second layer 30 is woven on top of the shrink first layer 20. This pattern alternates and repeats,
26 so that there are alternating blocks of yarns showing on both sides of the woven fabric. These
27 yarns in themselves are also woven into independent structures that are single layer fabrics. It
28 can be seen in Figure 2 that portions of the first layer 20 in a rectangular pattern are disposed
29 on the first side 36 of the second layer 30 and portions of the first layer 20 are disposed on the
30 second side 38 of the second layer 30. Further, it can be seen in Figure 2 that the pattern is
31 offset in repeating fashion. The rectangular pattern is provided for illustration only and should

1 not be deemed limiting. Such patterns include, but are not limited to squares, rectangles,
2 trapezoids, diamonds, circles, ovals, and the like.

3 As a result of the over and under weave patterns of the first layer 20, permeable, closed
4 cells 40 are created within the portion of the first layer 20 facing the first side 36 of the second
5 layer 30. Likewise, permeable, closed cells 40 are created within the portion of the first layer 20
6 facing the second side 38 of the second layer 30. The cells 40 are illustrated in Figures 3-5.
7 Figure 3 shows an end view of geotextile fabric 10 with the first layer 20 interwoven over and
8 under the second layer 30 in respective plain weaves. Figure 4 is also an end view of the fabric
9 10. In this illustration, the offset pattern of the over and under weave of the first layer 20 of the
10 bi-layer fabric 10 is shown. Cells 40, as particularly shown in Figure 5, are closed on all sides.
11 Further, Figure 5 is an illustration of a tented fabric 10.

12 During the tenting process, such as been exposed to hot water, steam, or heat in a
13 tenting oven under sufficient heat and/or temperature conditions and duration, the shrink
14 yarns shrink and the second layer 30 gathers and forms ridges 50 and valleys 60, as illustrated
15 in Figure 5. The pattern of the ridges 50 and valleys 60 depends on the weave of the second
16 layer 30 and the over and under woven pattern of the first layer 20. As further illustrated in
17 Figure 5, tenting causes respective portions of the first and second layers 20, 30 to space
18 apart from one another. Such separation provides for the respective cells 40 to have enclosed,
19 yet permeable, cavities capable of receiving soil and seeds. Further, the cells 40, ridges 50,
20 and valleys 60 provide an irregular shape for water disruption from either rain-splash or shear.
21 Further, because the fabric 10 has two layers of fabrics that are not in the same plane relative to
22 one another after shrinking, the fabric provides for a horizontal network of yarns that support
23 vegetation during the growth cycle.

24 Without limitation, the tented fabric 10 typically has a thickness between about 200
25 mils and about 750 mils. Yet, the tented fabric 10 can have a thickness which is less than 200
26 mils or greater than 750 mils. In another aspect, the thickness of the tented fabric 10 is 200,
27 250, 300, 350, 400, 450, 500, 550, 600, 650, 700, or 750 mils. The fabric 10 as illustrated in
28 Figure 5 has a thickness of about 250 mils (0.25 inch).

29 The fibers or monofilaments comprising the aforementioned yarns are typically
30 thermoplastic polymers. Additionally, yarns comprising natural fibers can be employed in the
31 present invention. Such natural yarns should be selected on their ability to with withstand the

1 heat and temperature of the tentering oven without being degraded or burned. Polymers which
2 may be used to produce the geotextile fabric of the present invention include, but are not limited
3 to, polyamides (for example, any of the nylons), polyimides, polyesters (for example, high
4 tenacity polyesters, polyethylene terephthalate, polybutylene terephthalate, and aromatic
5 polyesters, for example, Vectran[®]), polyacrylonitriles, polyphenylene oxides, fluoropolymers,
6 acrylics, polyolefins (for example, low density polyethylene (LDPE), linear low density
7 polyethylene (LLDPE), high density polyethylene (HDPE), co-polymers of polyethylene,
8 polypropylene, and higher polyolefins), polyphenylene sulfide, polyetherimide,
9 polyetheretherketone, polylactic acid (also known as polylactide), aramids (for example, para-
10 aramids, which include Kevlar[®], Technora[®], Twaron[®], and meta-paramids, for example,
11 Nomex[®], and Teijinconex[®]), aromatic ether ketones, vinalon, and the like, and blends of such
12 polymers which can be formed into microfilaments. Further, the fibers can comprise other
13 agents, materials, dyes, plasticizers, etc. which are employed in the textile industry. It will be
14 understood that any materials capable of producing fibers or microfilaments suitable for use in
15 the instant fabric of the present invention fall within the scope of the present invention.

16 As mentioned above, the respective fibers employed in the present invention can further
17 comprise at least one additive commonly used in conjunction with the material of the fiber.
18 Such additives include, but are not limited to, plasticizers, processing aids, scavengers, heat
19 stabilizers, antistatic agents, slip agents, dyes, pigments, antioxidants, ultraviolet light stabilizers,
20 metal deactivators, antistatic agents, flame retardants, lubricants, biostabilizers, and biocides.

21 The antioxidants, light stabilizers, and metal deactivators employed, if appropriate or
22 desired, can have a high migration fastness and temperature resistance. Suitable antioxidants,
23 light stabilizers, and metal deactivators include, but are not limited to, 4,4-diarylbutadienes,
24 cinnamic esters, benzotriazoles, hydroxybenzophenones, diphenylcyanoacrylates, oxamides
25 (oxalamides), 2-phenyl-1,3,5-triazines; antioxidants, nickel compounds, sterically hindered
26 amines, metal deactivators, phosphites and phosphonites, hydroxylamines, nitrones, amine
27 oxides, benzofuranones and indolinones, thiosynergists, peroxide scavengers, and basic
28 costabilizers.

29
30 Examples of suitable antistatic agents include, but are not limited to, amine derivatives
31 such as N,N-bis(hydroxyalkyl)alkylamines or -alkylenamines, polyethylene glycol esters and

ethers, ethoxylated carboxylic esters and carboxamides, and glycerol monostearates and distearates, and also mixtures thereof.

The additives are used in typical amounts as provided in the respective product literature. For example, the respective additives, when present, are in an amount from about 0.0001% to 10% by weight based upon the total weight of the fiber. In another aspect, the respective additives are present in an amount from about 0.01% to about 1% by weight based on the total weight of the respective fiber.

Any of the above polymers can be employed as "shrink" yarns, given a particular fabric construction. To recall, the shrink yarn shrinks at a lower temperature than the "non-shrink" yarn. The shrinkage properties are sufficiently different such that one yarn shrinks while the other does not.

Typically, the shrink and non-shrink yarns employed in the present invention further have the following properties:

	<u>Non-shrink Yarn</u>	<u>Shrink yarn</u>
Denier	250-2500	150-2500
Tensile strength (lb)	3 lb - 35 lb	1 lb - 20 lb
Elongation at brake (%)	5% - 35%	10% - 80%

Tensile strength and elongation are determined in accordance with American Society for Testing and Materials' (ASTM) Standard Test Method D-2256.

The geometrical cross-sectional shape of the yarns or monofilaments employed in the present invention can be of any shape. For example, the cross-sectional shape can be, but not limited to, round, oval, square, rectangular, trapezoidal, trilobal, multi-lobal, or other geometrically-shaped monofilaments.

Referring to Figure 6, the fabric 10 has the first layer 20 employing a honeycomb weave pattern. In this aspect, the first layer 20 employs shrink yarns in the warp and fill directions in its construction on a single plane and single layer of fabric. As illustrated, the second layer 30 is blocked in an over and under weave through the first layer 20. As illustrated, the second layer 30 is woven in a plain weave pattern through the second layer 20. As shown, the cells 40 are enclosed by the first and second layers 20, 30.

1 Again, referring to Figures 1-5, the fabric 10 has cells 40 in the bi-layer system which
2 break-up water flow and distributes the forces of rain and water run-off so that the effect of
3 erosion of the underlying soil, seeds, and vegetation are substantially reduced or prevented in
4 comparison to non-protected soil. This effect results in fewer washed out conditions on
5 channels and steepened slopes. The design of the bi-layer structure within the fabric 10 allows
6 provides the ability to reduce the amount of mass and yarns in the lower structure causing a
7 more open weave. This portion of the fabric 10 provides less surface area that touches the
8 ground and less impedance for germination. The soil contact of the fabric 10 is effectively
9 reduced; which facilitates better and faster germination.

10 Following the weaving process, the fabric 10 is essentially flat. Prior to tentering, the
11 fabric 10 thickness largely depends on the thickness of the respective monofilaments employed
12 to weave the first and second layers 20, 30. Typically, but not required, the pre-tentered fabric
13 10 has a thickness between about 20 mils and 75 mils. Yet, the pre-tentered fabric 10 can have
14 a thickness which is less than 20 mils or greater than 75 mils. The fabric is then subjected to a
15 heat setting or tentering process. For example, the untentered fabric 10 is placed on a "bed" of
16 open mesh fabric. Thereafter, the fabric 10 is exposed to heat in a tenter oven by pulling the
17 fabric through the hot air with sufficient tension necessary to pull the fabric through the oven.
18 The fabric 10 is allowed to "free-shrink." That is, the fabric is not restrained by mechanical
19 devices such as standard pins or clips. Typically, the fabric is processed through the tenter
20 oven at temperatures of about 200°F – about 240°F, for example with the shrink yarn is
21 polyethylene and the non-shrink yarn is polypropylene. It is understood by one of ordinary skill
22 in the art that the temperature range to be employed to tenter the fabric is dependent upon the
23 polymer employed as the shrink yarn. Again, the non-shrink yarns are selected such that they
24 do not shrink, or nominally shrink with respect to the shrink yarn, at the tentering temperature.
25 Further, the tentering temperature range can be varied depending upon the desired thickness
26 characteristics of the fabric and the dwell time of the fabric in the tenter oven. The purpose of
27 the tentering process is to subject the bi-layered fabric to sufficient heat for a sufficient duration
28 to permanently shrink the shrink yarn. As mentioned above, the shrinkage effect forces the
29 non-shrink yarns to buckle and create designed shapes that provide germination and root
30 support and can prevent and/or reduce soil loss and erosion.

31 After the above-described tentering process is conducted on the fabric 10, the respective
32 cells 40 have a length in the warp direction from about 0.40 mils to about 1.3 mils. Similarly, the
33 respective cells 40 have a width in the fill direction from about 0.40 mils to about 1.3 mils. In

1 one aspect, the respective cells have a length and width dimension of 0.87 x 0.87 mils. It is
2 readily apparent to one of ordinary skill in the art that the lengths and widths of the cells 40 of
3 the fabric 10 can be substantially the same or different depending upon the fabric density in the
4 warp and weft directions, respectively. Further, it is also readily apparent to one of ordinary skill
5 in the art that the cells 40 of the fabric 10 can differ in size and shape, again, based upon the
6 fabric density in the warp and weft directions, respectfully.

7 In another aspect of the present invention, after the above-described tentering process is
8 conducted on the fabric 10, the distance between the first and second layers 20, 30 of given cell
9 40 at the widest point therein is from about 100 mils to about 750 mils. In another aspect of the
10 present invention the distance between the first and second layers 20, 30 of a given cell 40 at
11 the widest point therein is from about 150 mils to about 350 mils. Yet, in another aspect of the
12 present invention the distance between the first and second layers of a cell 40 at the widest
13 point therein is about 200 mils.

14 With respect to the above description then, it is to be realized that the optimum
15 dimensional relationships for the parts of the invention, to include variations in size, materials,
16 shape, form, function and manner of operation, assembly and use, are deemed readily apparent
17 and obvious to one skilled in the art, and all equivalent relationships to those illustrated in the
18 drawings and described in the specification are intended to be encompassed by the present
19 invention.

20 Therefore, the foregoing is considered as illustrative only of the principles of the
21 invention. Further, various modifications may be made of the invention without departing from
22 the principles described herein.

WE CLAIM:

1. A bi-layer, woven geotextile fabric comprising:
a first layer comprising monofilaments respectively woven in warp and fill directions;
a second layer comprising monofilaments respectively woven in warp and fill directions
and having first and second sides;
the first layer over and under woven through the second layer in a pre-determined pattern so that the first layer has portions which face the first side of the second layer and portions which face the second side of the second layer;
the monofilaments in the warp direction of the first layer having a pre-determined differential heat shrinkage characteristic greater than the monofilaments in the warp direction of the second layer; and
cells disposed on the first and second sides of the second layer and respectively defined by the pattern of the over and under weave of the first layer, and each cell defining a permeable, enclosed cavity.
2. The fabric of Claim 1, wherein the fabric is a tentered fabric.
3. The fabric of Claim 1, wherein each cell has a portion of the first layer that is spaced apart from a portion of the second layer.
4. The fabric of Claim 1, wherein the warp and fill monofilaments of the first layer comprise the same material.
5. The fabric of Claim 1, wherein the warp and fill monofilaments of the second layer comprise the same material.
6. The fabric of Claim 1, wherein the pattern is a repeating pattern on the first and second sides of the second layer.
7. The fabric of Claim 1, wherein the monofilaments are made from polyamides, polyimides, polyesters, polyacrylonitriles, polyphenylene oxides, fluoropolymers, acrylics, polyolefins, polyphenylene sulfide, polyetherimide, polyetheretherketone, polylactic acid, aramids, aromatic ether ketones, vinalon, and any blend of such polymers formable into the monofilament.
8. The fabric of Claim 7, wherein the monofilaments include natural fibers.

9. The fabric of Claim 1, wherein the monofilaments in the warp direction of the first layer comprise polyethylene and the monofilaments in the warp direction of the second layer comprise polypropylene.

10. The fabric of Claim 1, wherein the fabric further comprises at least one additive, the at least one additive being a plasticizer, a processing aid, a scavenger, a heat stabilizer, an antistatic agent, a slip agent, a dye, a pigment, an antioxidant, an ultraviolet light stabilizer, a metal deactivator, an antistatic agent, a flame retardant, a lubricant, a biostabilizer, or a biocide.

11. The fabric of Claim 1, wherein the fabric further comprises an ultraviolet light stabilizer.

12. The fabric of Claim 2, wherein respective cells have a length in the warp direction from about 0.40 mils to about 1.3 mils and a width in the fill direction from about 0.40 mils to about 1.3 mils, and the measurements of the length and width of a respective cell are the same or different.

13. A bi-layer, woven geotextile fabric comprising:
a first layer comprising monofilaments respectively woven in warp and fill directions;
a second layer comprising monofilaments respectively woven in warp and fill directions and having first and second sides;

the first layer over and under woven through the second layer in a pre-determined pattern so that the first layer has portions which face the first side of the second layer and portions which face the second side of the second layer;

the monofilaments in the warp and fill directions of the first layer having a pre-determined differential heat shrinkage characteristic greater than the respective monofilaments in the warp and fill directions of the second layer; and

cells disposed on the first and second sides of the second layer and defined by the pattern of the over and under weave of the first layer, and each cell defining a permeable, enclosed cavity.

14. The fabric of Claim 13, wherein the fabric is a tented fabric.

15. The fabric of Claim 13, wherein each cell has a portion of the first layer that is spaced apart from a portion of the second layer.

16. The fabric of Claim 13, wherein the pattern is a repeating pattern on the first and second sides of the second layer.

17. The fabric of Claim 13, wherein the monofilaments are made from polyamides, polyimides, polyesters, polyacrylonitriles, polyphenylene oxides, fluoropolymers, acrylics, polyolefins, polyphenylene sulfide, polyetherimide, polyetheretherketone, polylactic acid, aramids, aromatic ether ketones, vinalon, any blend of such polymers formable into the monofilament, and natural fibers.

18. The fabric of Claim 13, wherein the first layer comprises polyethylene and the second layer comprises polypropylene.

19. The fabric of Claim 13, wherein the fabric further comprises at least one additive, the at least one additive being a plasticizer, a processing aid, a scavenger, a heat stabilizer, an antistatic agent, a slip agent, a dye, a pigment, an antioxidant, an ultraviolet light stabilizer, a metal deactivator, an antistatic agent, a flame retardant, a lubricant, a biostabilizer, or a biocide.

20. The fabric of Claim 13, wherein the fabric further comprises an ultraviolet light stabilizer.

21. The fabric of Claim 14, wherein respective cells have a length in the warp direction from about 0.40 mils to about 1.3 mils and a width in the fill direction from about 0.40 mils to about 1.3 mils, and the measurements of the length and width of a respective cell are the same or different.

22. A bi-layer, woven geotextile fabric comprising:
a first layer comprising monofilaments respectively woven in warp and fill directions;
a second layer comprising monofilaments respectively woven in warp and fill directions
and having first and second sides;

the first layer over and under woven through the second layer in a pre-determined pattern so that the first layer has portions which face the first side of the second layer and portions which face the second side of the second layer; and

cells disposed on the first and second sides of the second layer and respectively defined by the pattern of the over and under weave of the first layer, and each cell defining a permeable, enclosed cavity and having a portion of the first layer that is spaced apart from a portion of the second layer.

23. The fabric of Claim 22, wherein the warp and fill monofilaments of the first layer comprise the same material.

24. The fabric of Claim 22, wherein the warp and fill monofilaments of the second layer comprise the same material.

25. The fabric of Claim 22, wherein the monofilaments are made from polyamides, polyimides, polyesters, polyacrylonitriles, polyphenylene oxides, fluoropolymers, acrylics, polyolefins, polyphenylene sulfide, polyetherimide, polyetheretherketone, polylactic acid, aramids, aromatic ether ketones, vinalon, any blend of such polymers formable into the monofilament, and natural fibers.

26. The fabric of Claim 22, wherein the first layer comprises polyethylene and the second layer comprises polypropylene.

27. The fabric of Claim 22, wherein the fabric further comprises at least one additive, the at least one additive being a plasticizer, a processing aid, a scavenger, a heat stabilizer, an antistatic agent, a slip agent, a dye, a pigment, an antioxidant, an ultraviolet light stabilizer, a metal deactivator, an antistatic agent, a flame retardant, a lubricant, a biostabilizer, or a biocide.

28. The fabric of Claim 22, wherein the fabric further comprises an ultraviolet light stabilizer.

29. A bi-layer, woven geotextile fabric comprising:
a first layer comprising polyethylene monofilaments respectively woven in warp and fill directions;
a second layer comprising polypropylene monofilaments respectively woven in warp and fill directions and having first and second sides;
the first layer over and under woven through the second layer in a pre-determined pattern so that the first layer has portions which face the first side of the second layer and portions which face the second side of the second layer; and
cells disposed on the first and second sides of the second layer and respectively defined by the pattern of the over and under weave of the first layer, and each cell defining a permeable, enclosed cavity having a portion of the first layer spaced apart from a portion of the second layer.

30. A bi-layer, woven geotextile fabric comprising:

a first layer comprising monofilaments respectively woven in warp and fill directions;
a second layer comprising monofilaments respectively woven in warp and fill directions
and having first and second sides;
the first layer over and under woven through the second layer in a pre-determined
pattern so that the first layer has portions which face the first side of the second layer and
portions which face the second side of the second layer;
the monofilaments in the fill direction of the first layer having a pre-determined
differential heat shrinkage characteristic greater than the monofilaments in the fill direction of the
second layer; and
cells disposed on the first and second sides of the second layer and respectively defined
by the pattern of the over and under weave of the first layer, and each cell defining a permeable,
enclosed cavity.

31. The fabric of Claim 30, wherein the fabric is a tentered fabric.

32. The fabric of Claim 30, wherein each cell has a portion of the first layer that is
spaced apart from a portion of the second layer.

33. The fabric of Claim 30, wherein the pattern is a repeating pattern on the first and
second sides of the second layer.

34. The fabric of Claim 30, wherein the monofilaments are made from polyamides,
polyimides, polyesters, polyacrylonitriles, polyphenylene oxides, fluoropolymers, acrylics,
polyolefins, polyphenylene sulfide, polyetherimide, polyetheretherketone, polylactic acid,
aramids, aromatic ether ketones, vinalon, any blend of such polymers formable into the
microfilament, and natural fibers.

35. The fabric of Claim 30, wherein the monofilaments in the fill direction of the first
layer comprise polyethylene and the monofilaments in the fill direction of the second layer
comprise polypropylene.

36. The fabric of Claim 30, wherein the fabric further comprises at least one additive,
the at least one additive being a plasticizer, a processing aid, a scavenger, a heat stabilizer, an
antistatic agent, a slip agent, a dye, a pigment, an antioxidant, an ultraviolet light stabilizer, a
metal deactivator, an antistatic agent, a flame retardant, a lubricant, a biostabilizer, or a biocide.

37. The fabric of Claim 30, wherein the fabric further comprises an ultraviolet light stabilizer.

38. The fabric of Claim 31, wherein respective cells have a length in the warp direction from about 0.40 mils to about 1.3 mils and a width in the fill direction from about 0.40 mils to about 1.3 mils, and the measurements of the length and width of a respective cell are the same or different.

39. The fabric of Claim 2, wherein the first and second layers of respective cells are spaced apart at the widest point therein about 200 mils.

40. The fabric of Claim 31, wherein the first and second layers of respective cells are spaced apart at the widest point therein about 200 mils.

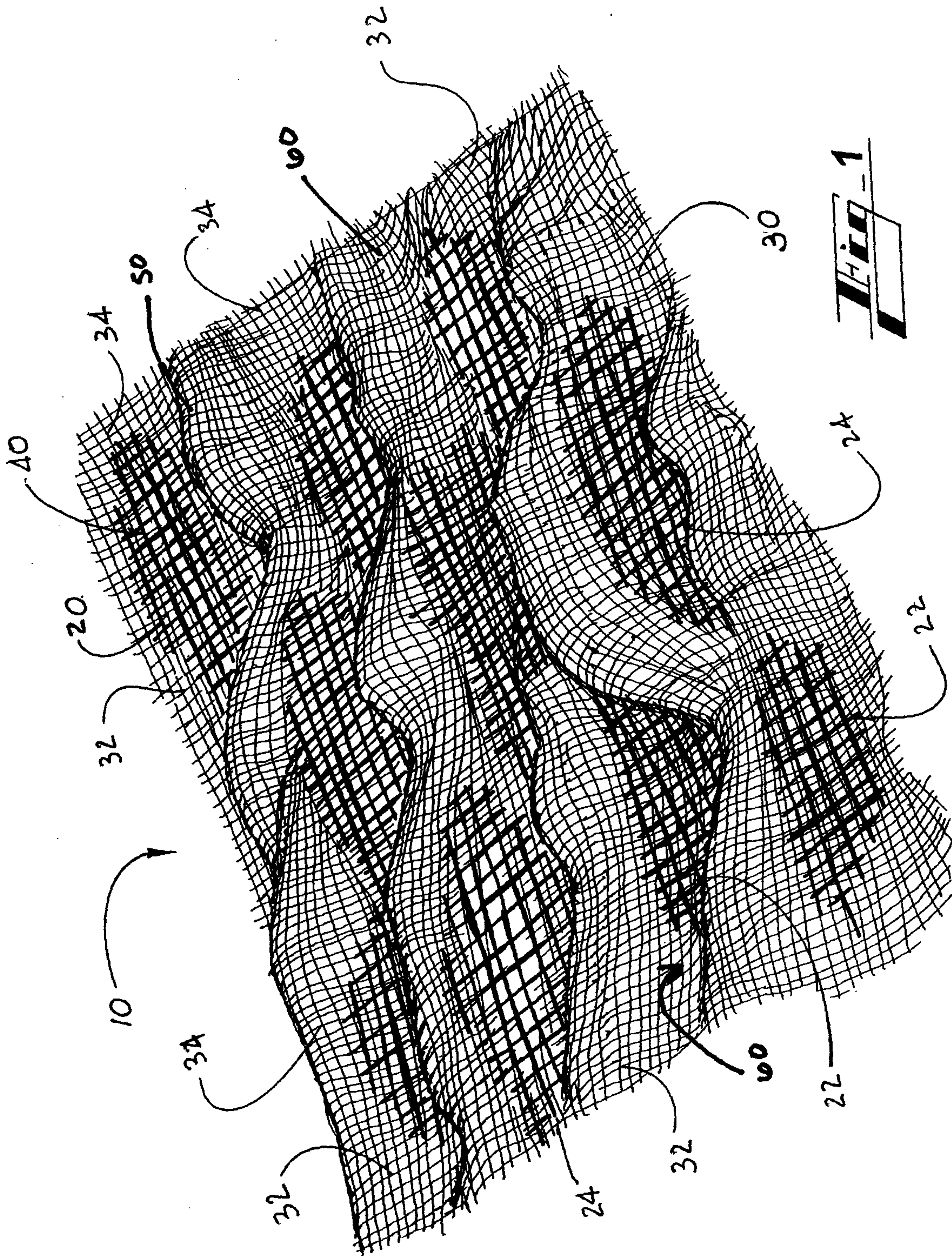


Fig. 1

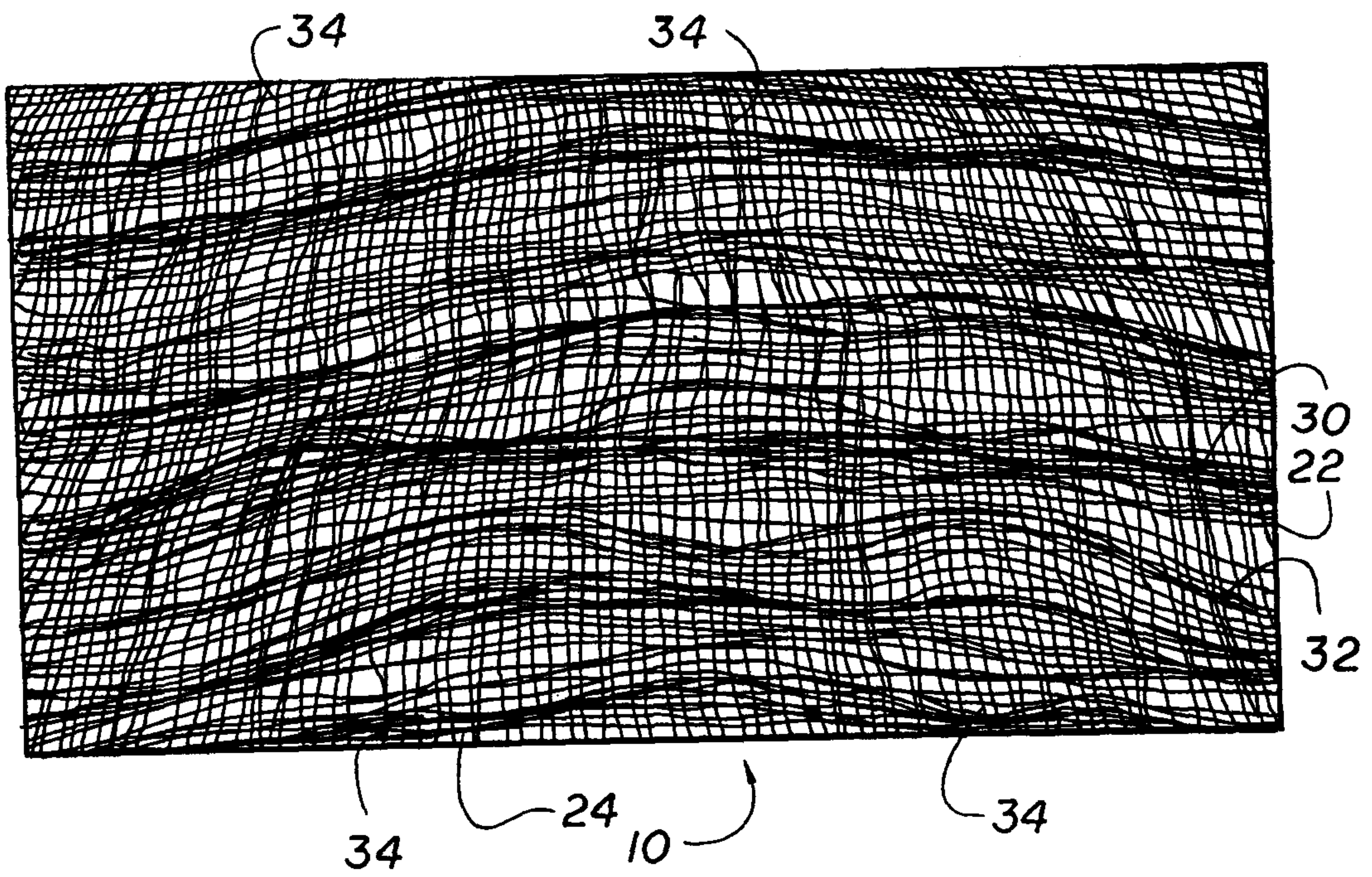


Fig. 2

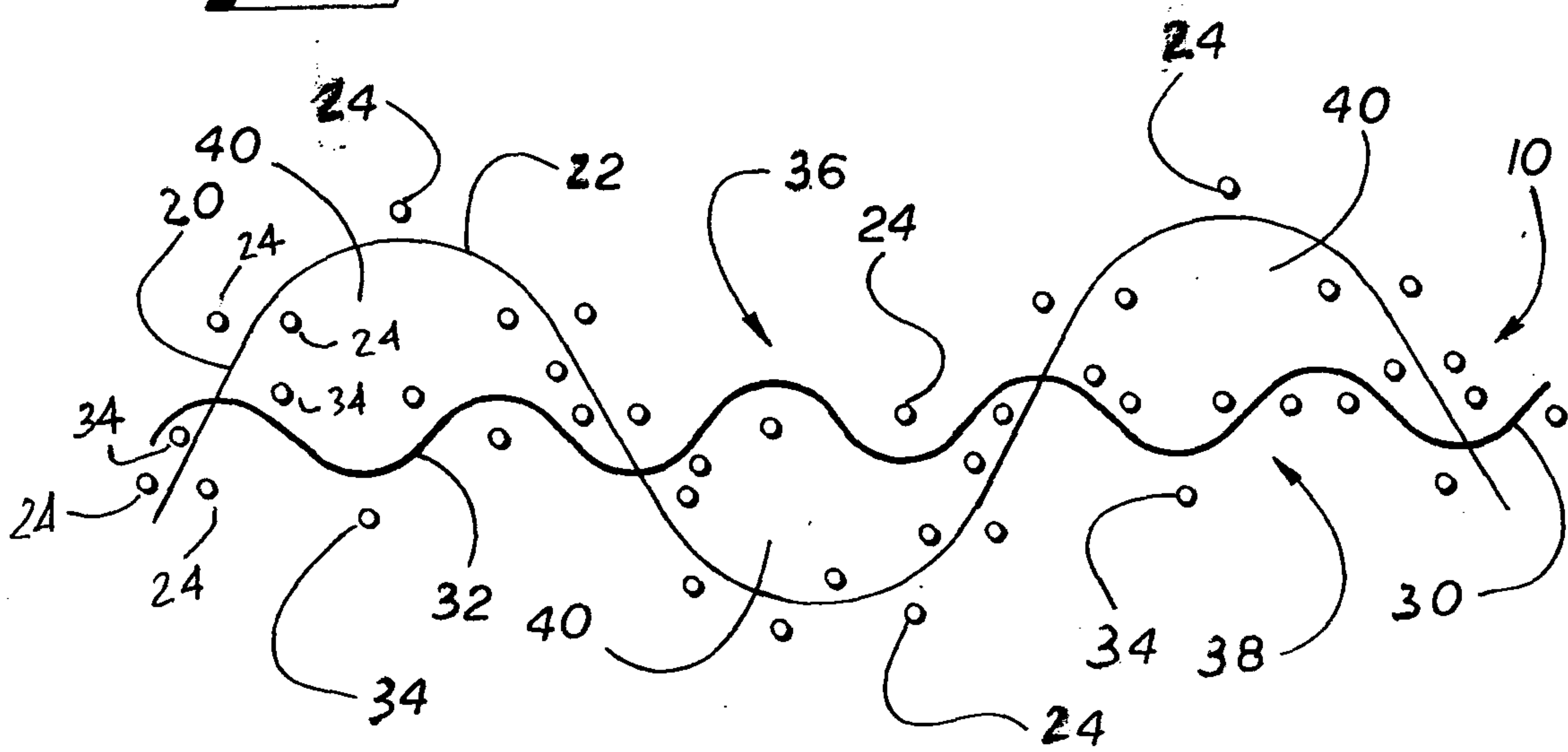


Fig. 3

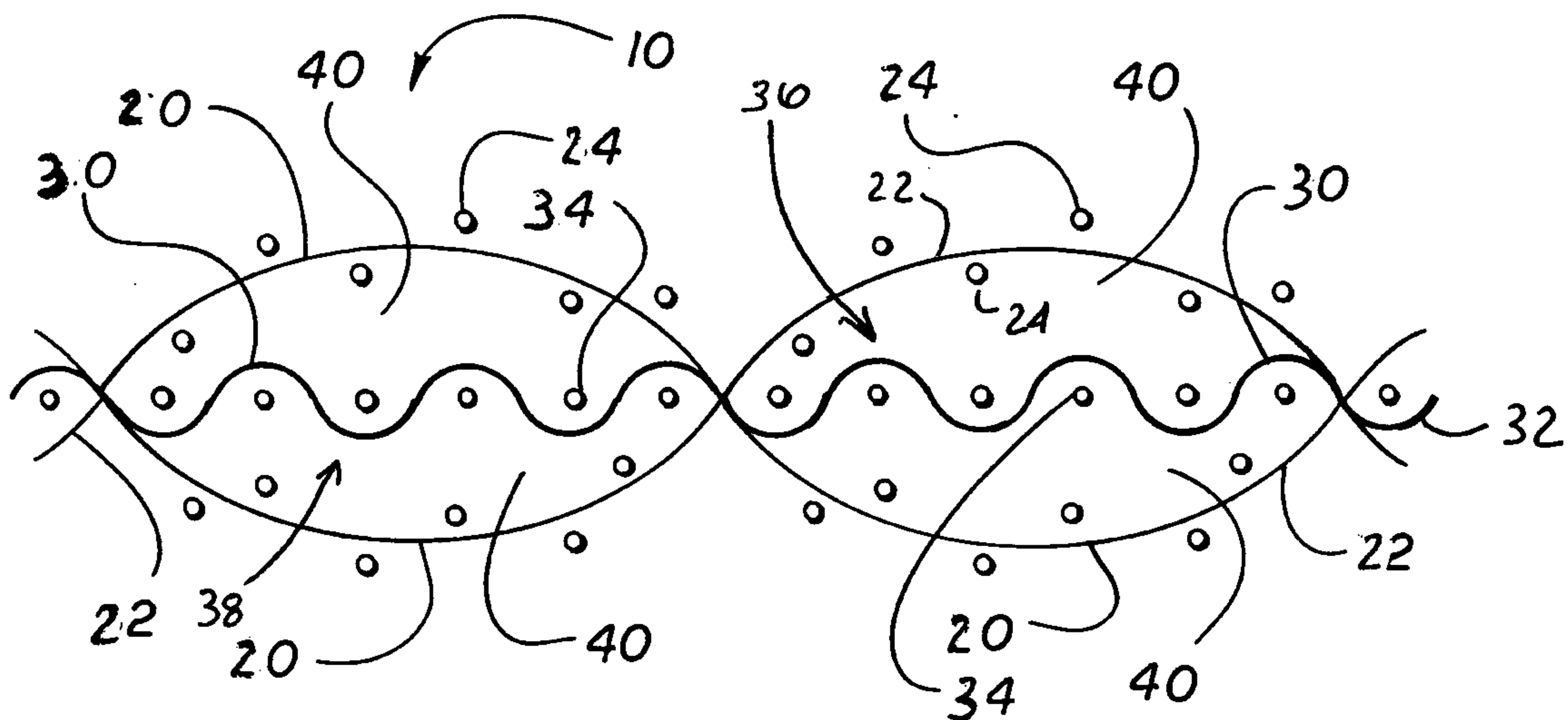


Fig. 4

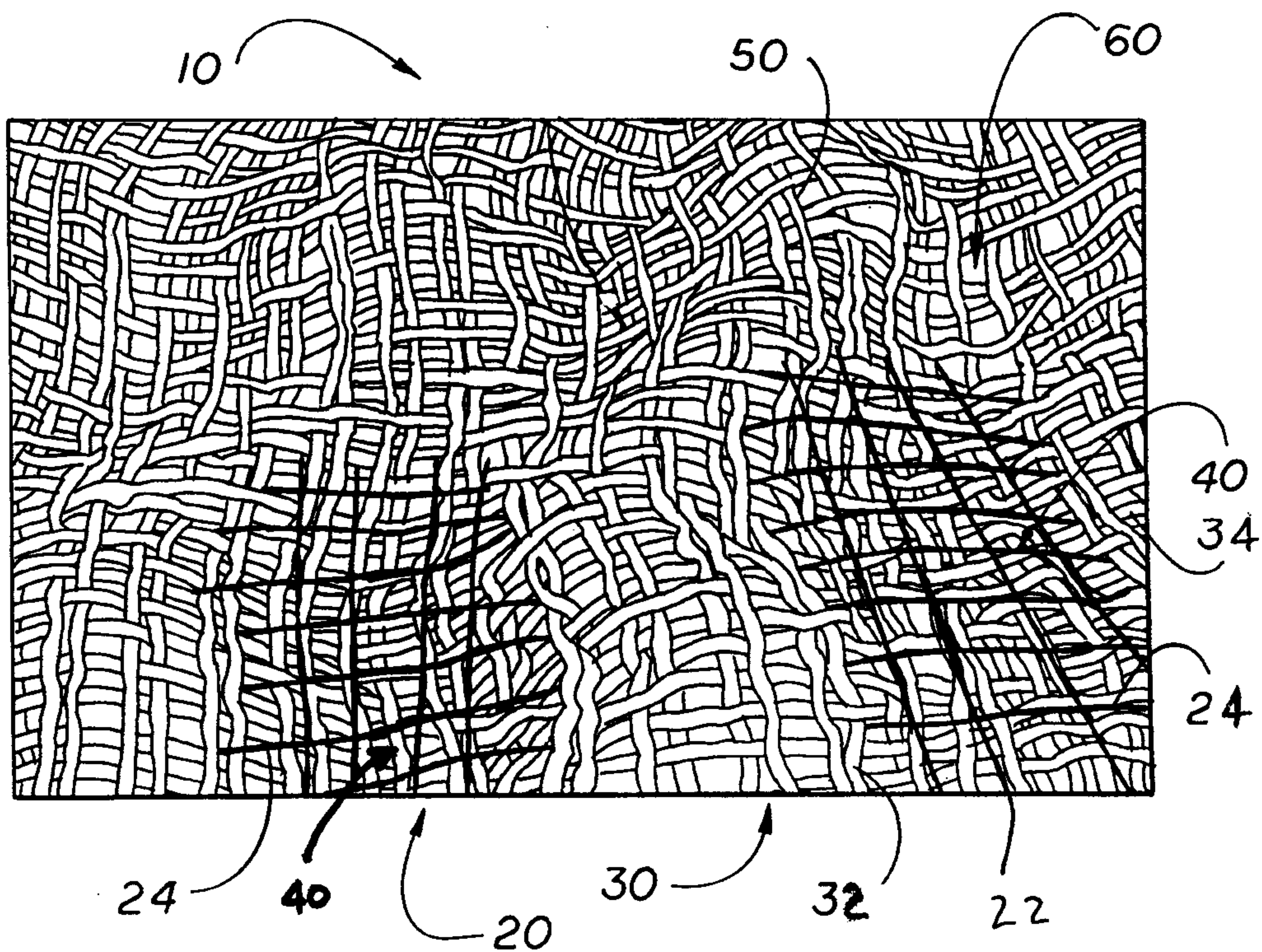


Fig. 5

