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54 **Vented cell material for confinement of concrete and earth materials.**

57 An earth confinement material (10) having vent openings (12) between adjacent cells (14) provides improved structural integrity in single layer and multilayer filled cell structures and allows venting of water and entrapped gases from certain fill materials (32). The vent openings can also be used for connecting adjacent cell sections using cable (100), nut and bolt assemblies, or the like. The vented earth confinement structures can be used with a wide variety of fill materials (32) including sand, soil, cement, asphalt, gravel, and industrial spoil materials.

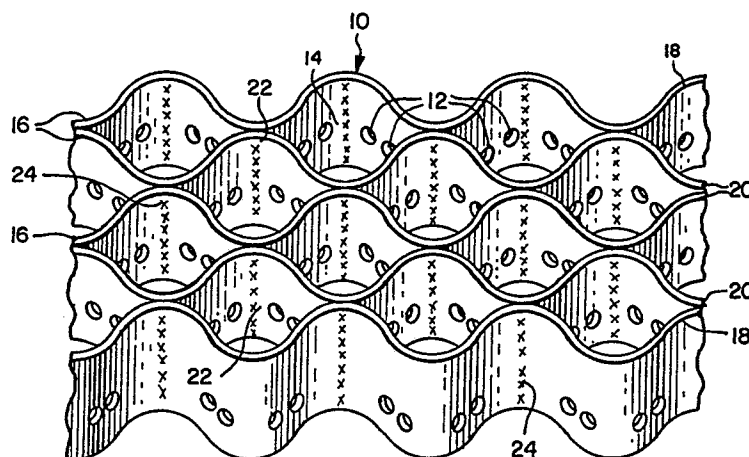


FIG. 1

VENTED CELL MATERIAL FOR CONFINEMENT OF CONCRETE AND EARTH MATERIALS

The present invention relates to a vented cell material for concrete, asphalt and earth confinement. Specifically, the invention relates to a cell material having vents in the walls of the cells.

A section of cells used for soil confinement to provide a road base made from soils (sand, rounded rock, poorly graded aggregate, concrete and the like) has been known and used for some time. A prime example is Geoweb™ plastic cell soil confinement system, sold by Reynolds Consumer Products, Inc., P.O. Box 2399, Appleton, Wisconsin 54913. Geoweb™ cells are made from plastic strips which are joined on their faces in a side by side relationship at alternating spacings so that when the strips are stretched out in a direction perpendicular to the faces of the strips, the resulting cell section is honeycomb-like in appearance, with sinusoidal or undulant shaped cells.

Voluminous reports have proved the ability of Geoweb™ cell material to support roadways. Geoweb™ cell material has also been used in applications where the cell layers are stacked on one another, such as a stepped back design for hill slope retention. Even free standing walls have been built with Geoweb™ cells. However, because the cells are completely enclosed on the sides, the ability of the filled structures to withstand upward and downward pressure can be limited by the sometimes low adhesive and/or frictional forces between the filler material and the walls of the cells. Furthermore, the cells can retain water which is originally present in the filler material or hydraulic drainage which later enters as a result of rain, snow, etc. Such entrained water can reduce the structural integrity and cause erosion of structures made from concrete, asphalt, or loose earth materials. Additionally, the presence of entrained water can cause cracking and separation of structures made using concrete or asphalt fillers, resulting from freezing and thawing of the water.

The present invention provides a cell material having vent openings in the walls of the cells. These openings cause improved structural integrity of concrete, asphalt, and gravel structures by providing for continuity between the concrete, asphalt, or gravel confined in the different cells. Furthermore, these openings provide a means for venting excess water from the cells, causing further improvements in the structural integrity of gravel, concrete, asphalt or earth structures and preventing structural deterioration caused by the infusion of water into the structures. Finally, these openings provide an improved means of tying adjacent sections together using cables or tendons as well as providing an additional means of securing J-hook

anchor pins to the cell material.

The openings between the cells may vary in size, shape, and number depending on the specific application, the properties required, the size and type of the fill material, and the size of the cells. Depending on the application, the vented cell material may either consist of a single layer of cell material or a plurality of cell layers stacked on top of each other. The venting may be uniform throughout the structure or may be varied in any desired fashion.

The embodiments and advantages of the invention are further described in the following detailed description made with reference to the accompanying Figures.

FIGURE 1 is a perspective view of a single layer vented cell material of the invention.

FIGURE 2 shows the vented cell material of FIGURE 1 filled with concrete.

FIGURE 3 is a top sectional view of a single layer concrete-filled structure.

FIGURE 4 is a perspective view of the vented cell material of the invention, stacked in multiple layers and filled with gravel to form a wall.

FIGURE 5 is a front sectional view of the gravel-filled structure of FIGURE 4.

FIGURE 6 illustrates one use of the vented cell material of the invention, to reinforce a gravel road on the side of a mountain.

FIGURE 7 is an exploded sectional view of the structure of FIGURE 6 showing the path of water in a rainstorm.

FIGURE 8 illustrates the use of the vented cell material of the invention to control the erosion of a channel bed. Adjacent sections of cell material are tied together with cable as illustrated in FIGURE 9.

Referring to FIGURE 1, a single-layer cell structure 10 is shown having vent openings 12 communicating between adjacent cells 14. The cells 14 are preferably formed by first bonding a plurality of plastic strips 16 in side by side relationship, using ultrasonic welding as discussed in U.S. Patent 4,572,753 and U.S. Patent 4,647,325. The bonding between strips may best be described by thinking of the strips 16 as being paired, starting with an outside strip 18 paired to an outermost inside strip 20, a pair of the next two inside strips 20, etc. The two strips 16 of each pair are preferably bonded together at bonding areas 22 located at substantially equal intervals along the length of the strips. Each pair of strips 16 is bonded to each adjacent pair at bonding areas 24 located about halfway between the bonding areas 22. The cell structure 10 can be formed by pulling the plurality

of bonded plastic strips 16 in a direction perpendicular to the faces of the strips 16, causing the plastic strips to bend in a sinusoidal fashion. The width of the strips can vary depending on the desired cell depth. Examples of typical widths are 2-5/8 inches, four inches, and eight inches.

The vented openings 12 may be formed by any suitable method either before or after the plastic strips 16 are bonded together. In a preferred method, the vents are formed by drilling holes through several adjacent strips after the strips have been bonded together. In the embodiment shown in FIG. 1, the vent openings are present in pairs in a repeating pattern such that each cell 14 has eight openings communicating with each adjacent cell and/or with the outside. The size and number of vent openings can vary as can the size and number of the strips 16 which form the cell walls. The location of the holes within the strips can also vary. In the embodiment which forms the basis for FIG. 1, each strip is about eight inches high and the welds 22 are formed at lengthwise intervals of about thirteen inches. Each weld 24 is about 6-1/2 inches from a weld 22 in the embodiment shown, though this dimension can vary depending on the desired cell size. The openings have diameters of about one-half of an inch and are formed in pairs.

One opening of each pair is between about two and 2.5 inches from the nearest weld (22 or 24). The second opening of each pair is spaced at between two and 2.5 inches from the first opening (measured center to center). Each opening is centered at about two-thirds of the distance from the top of the strip and about one-third of the distance from the bottom of the strip. The size, number, and location of the openings can also be varied depending on the application and on the depth of the cells. For instance, the vent openings may be formed about halfway between the top and bottom of the strips.

FIGURES 2 and 3 illustrate the use of the vented cell material of the invention filled with concrete, such as is used for reinforcing a concrete channel liner. The channel may be man-made or natural. A concrete material 32, generally confined within the individual cells 14, is connected between adjacent cells at the vent openings 12 to form a continuous interlocking network throughout the cell structure as shown in FIG. 3. This interlocking between adjacent cells causes the filled structure to have reduced long-term settling and greater load bearing capacity than filled cell structures which do not have communication between adjacent cells. Load bearing capacity is a measure of the ability of the concrete filled cell structure to withstand vertical pressures including, for instance, localized uplift pressures caused by freezing temperatures and water pressure from underground springs.

As the load bearing capacity is increased, the capacity of the concrete liner for withstanding pressures caused by shifting of the earth and pedestrian, animal and vehicle traffic is also increased. Furthermore, the concrete channel liner is better able to conform to differential settlement of the surrounding earth without losing structural integrity.

While the foregoing is explained with reference to a concrete channel liner, it is understood that similar advantages would result if the vented cell material of the invention were used to reinforce walls, roadways, and other fill material structures. In such structures, the cell material and the fill material reinforce one another. The cell material helps prevent expansion, erosion, cracking, breaking, and lateral spreading of the fill material. The fill material, interconnected at the vent openings, helps prevent vertical movement, distortion, and separation of the cell material.

In addition to reinforcement of hydraulic channels, there are numerous other applications for single-layer vented cell material of the invention including the prevention of erosion on hillsides, shorelines, and roadways. When used to reinforce hillsides, the cells contain and prevent erosion of soil while the vent openings allow water which is underneath the surface to "trickle down" the hill. When used on shorelines, the cells contain and prevent erosion of rocks and sand while the water entering the cells as a result of waves, high tide, etc. gradually trickles back to the lake, ocean or sea through the vent openings. The vent openings also provide a means for anchoring the reinforced structure, as hereinafter discussed with reference to FIGS. 8 and 9.

FIGURES 4 and 5 exemplify the use of multiple layers of vented cells material stacked upon one another and filled with sand, gravel, soil, concrete, asphalt, slag, or another earth material 42 to form a wall generally designated as 40. Preferably, the cell layers are stacked upon one another using the notching techniques disclosed in U.S. Application Serial No. 07/032,278, the entire disclosure of which is incorporated herein by reference. As illustrated in FIG. 5, the vent openings 12 cause interlocking between the fill material in adjacent cells 14, throughout the entire wall. This interlocking causes an improvement in structural integrity which greatly increases the ability of the wall to withstand pressure and impact of both vertical and horizontal origins. If the wall is filled with a loose or porous material, the vent openings also provide for drainage of water and entrapped gases.

Depending on the specific application, it may not always be desirable to have vent openings in all of the layers of cells or in all of the plastic strips of a given cell layer. In FIGURE 4, for example, the outer plastic strips 18 may alternatively be pro-

vided without vent openings in order to prevent escape of some of the fill material. When water drainage is a primary objective of the vented cell structure, it may be desirable to vent only some of the layers (e.g. the lowermost layers, or alternating layers). Furthermore, when a single-layer cell structure is used to reinforce the slope of a hill, it may be desirable to vent only some of the cells (e.g. the center cells) within the layer.

FIGURES 6 and 7 illustrate the use of vented cell material of the invention to reinforce a gravel road 50 located on the side of a mountain 60, thereby preventing erosion and possible washout of the road. FIGURE 7 illustrates the path of water during a rainstorm. Rainwater 62 enters the gravel material 52 of the road 50 both from the sky and from the mountain side. The rainwater initially travels downward through the gravel material 52 and is confined, with the gravel, between the cell walls 16 of the individual cells 14 and an impermeable liner 15 placed beneath the cell structure. As the individual cells 14 begin to fill up with water between the gravel particles, the water begins to flow horizontally through the vent openings 12 in the cells walls 16. The water flows horizontally through the openings 12 until it reaches the edge of the road, where it continues down the side of the mountain.

In other words, the rapid flow of rainwater 62 which exists on the mountainside 60 is minimized on the surface of the road 50. The vent openings 12 cause the water to flow beneath the surface of the road, thereby helping alleviate puddle formation, erosion, and slippery conditions at the surface. The cell walls 16 prevent lateral erosion of the gravel material 52. The impermeable liner 15 helps alleviate settling of the fill material. The net result is a longer lasting mountainside road which is safer for travel during adverse weather conditions.

In addition to gravel roads, the vented cell material of the invention may be used to reinforce roads made from concrete, asphalt, and other materials. Due to an increase in load bearing capacity attributable to the vented cell material, such roadways are better able to withstand heavy vehicle traffic than roads which have not been reinforced using vented cell material. Furthermore, roadways built using the vented cell material of the invention are more resistant to pothole formation, buckling, and damage caused by erosion and shifting.

FIGURE 8 illustrates the use of a vented cell structure 10 in place at the bottom of a natural stream to prevent erosion of the channel bed 70. In some geographic regions, it has been difficult to build lasting bridges across channels or streams because continual erosion of the channel bed causes washout of the bridges. By using cell material to prevent erosion of the channel 70, low water crossings can be built across the channel 70

allowing vehicles, pedestrians, and animals to travel from one side 72 of the channel to the other side 74. Entrances and exits 76 and 78 for crossing the channel bed 70 can be provided at different locations along the length of the channel by reinforcing the side of the channel with vented cell material.

An application such as that illustrated in FIGURE 8 requires numerous adjacent sections of cell material connected together in a horizontal fashion. As shown in FIGURES 8 and 9, the vent openings 12 provide a convenient means for connecting adjacent sections together using a cable 100. The cable 100 is passed through the openings 12 in the outer layers 18 of the adjacent sections such as to "sew" the sections together. The cable 100 is then knotted, clamped, or fastened to an anchor system 102 at both ends as shown.

FIGURE 9 illustrates only one of several possible techniques for connecting adjacent sections of vented cell material together using the vented openings 12. For example, other fastening means such as nuts and bolts may be utilized by positioning the adjacent cell sections so that the outer layers 18 are parallel to one another and the vent openings 12 in the outer layers line up between the adjacent sections. Furthermore, additional lengths of cable may be passed through the vent openings in the inner plastic strips 20 to provide additional reinforcement for the cell structure.

Additional cables, such as the cable 200 shown in FIGURE 9, may be threaded between the vented cells in order to provide additional reinforcement and/or to help anchor the vented cell structure. Any number of cables may be utilized for the purpose, depending on the degree of reinforcement and/or anchoring required.

While the preferred embodiments of the invention have been disclosed, it is understood that the invention is not limited to the disclosed examples. For instance, different fill materials may be utilized including concrete, asphalt, sand, soil, and other earth materials. The fill material may also be an industrial spoil material such as mine tailings or fly ash. The type of fill material and the configuration of the cell material, including the size, number and location of the vent openings, will vary depending on the use. Modifications in addition to those discussed can be made without departing from the invention.

The scope of the invention is indicated in the appended claims. All changes that come within the meaning and range of equivalency of the claims are intended to be embraced therein.

Claims

1. A vented cell structure for confinement of

earth materials comprising:

a plurality of plastic strips bonded together on their faces in a side by side relationship at bonding areas which are staggered from strip to strip such that the plurality of strips may be stretched in a direction perpendicular to the face of the strips to form a layer of cells;

said strips comprising two outside strips and one or more inside strips;

at least one of said strips having openings;

said strips forming cell walls;

said openings forming passages through at least one of said cell walls.

2. The vented cell structure of Claim 1, wherein the inside strips have openings forming passages between adjacent cells.

3. The vented cell structure of Claim 2, wherein the inside strips have openings formed in a regular fashion such that each cell has the same number of openings communicating with each adjacent cell.

4. The vented cell structure of any of Claims 1 to 3, wherein the openings in the strips are formed such that the centers of the openings are located in the cell walls closer to the bottom of the cell layer than to the top of the cell layer.

5. The vented cell structure of any of Claims 1 to 4, wherein the openings in the strips are formed such that the centers of the openings are located in the cell walls closer to the bottom of the cell layer than to the top of the cell layer.

6. The vented cell structure of Claim 5, wherein the openings in the strips are formed such that the centers of the openings are located in the cell walls about two-thirds of the distance between the top of the cell layer and the bottom of the cell layer.

7. The vented cell structure of any of Claims 1 to 4, wherein the openings in the strips are formed such that the centers of the openings are located in the cell walls about halfway between the top of the cell layer and the bottom of the cell layer.

8. A multilayer vented cell structure comprising a plurality of the cell layers of any of Claims 1 to 7 stacked on top of one another.

9. The multilayer vented cell structure of Claim 8, wherein the inside strips have top and bottom edges which are notched such that the cell layers stacked upon one another rest with portions of the cell walls overlapping each other.

10. A vented cell structure comprising at least two adjacent sections of the vented cells of any of Claims 1 to 9 joined horizontally by inserting a cable through openings in adjacent outer strips.

11. The vented cell structure of any of Claims 1 to 10 wherein each strip has a width of about 2 5/8 inches.

12. The vented cell structure of any of Claims 1 to 10, wherein each strip has a width of about four inches.

13. The vented cell structure of any of Claims 1 to 10, wherein each strip has a width of about 8 inches.

14. The vented cell structure of any of Claims 11 to 13, wherein each strip is bonded to an adjacent strip at lengthwise intervals of about 6 1/2 inches and to each adjacent strip at lengthwise intervals of about thirteen inches.

15. The vented cell structure of Claim 14, wherein the openings in the strips are substantially circular and have diameters of about one-half of an inch.

16. The vented cell structures of any of Claims 1 to 15, wherein the openings in the strips are formed in such fashion that each cell has two openings communicating with each adjacent cell.

17. A reinforced earth material structure comprising:

a layer of cells formed by bonding a plurality of strips together on their faces in a side by side relationship at bonding areas which are staggered from strip to strip and then stretching the plurality of strips in a direction perpendicular to the faces of the strips; and

a fill material within the cells;

said strips comprising two outside strips and one or more inside strips;

said strips forming cell walls and having openings which communicate between said cells;

said fill material in adjacent cells communicating at said openings to form a continuous interlocking material network.

18. The reinforced earth material structure of Claim 17, wherein the strips comprise a plastic material.

19. The reinforced earth material structure of Claim 17, wherein the fill material comprises cement, asphalt, soil, sand, gravel, or industrial spoil material.

20. The reinforced earth material structure of any of Claims 17 to 19 comprising at least two layers of filled cell material stacked in a vertical fashion.

21. The reinforced earth material structure of any of Claims 17 to 20 comprising at least two adjacent sections of cell material joined horizontally by inserting a cable through openings in adjacent outer strips.

22. A method of making a vented cell structure for confinement of earth materials comprising the steps of:

bonding a plurality of plastic strips together on their faces in a side by side relationship at bonding areas which are staggered from strip to strip;

forming vents in the plastic strip by forming holes through the plurality of strips;

stretching the plurality of strips in a direction perpendicular to the faces of the strips to form a cell

layer having a plurality of vented cells.

23. The method of Claim 22 further comprising the step of stacking at least two layers of cell material on top of one another to form a multilayer cell structure.

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24. The method of Claim 23 further comprising the step of forming notches in the edges of the plastic strips such that the layers of cell material stacked on top of one another rest with portions of the cell walls on a perimeter of the cell overlapping each other.

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25. The method of any of Claims 22 to 24, wherein the bonding of the strips is accomplished by forming ultrasonic welds substantially traversing the width of the strips.

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26. A method of making a vented, reinforced earth material structure comprising the steps of: forming a layer of cell material having a repeating pattern of cell structures with thin cell walls between the cells and open tops and bottoms; forming vents in the cell walls which communicate between adjacent cells; and substantially filling the cells with a fill material such that the fill material in the adjacent cells communicates through said vents to form a continuous interlocking network of fill material.

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27. The method of Claim 26 further comprising the step of stacking two or more layers of cell material on top of one another.

28. The method of Claim 26 or Claim 27, wherein the fill material comprises a concrete material or loose particulate material.

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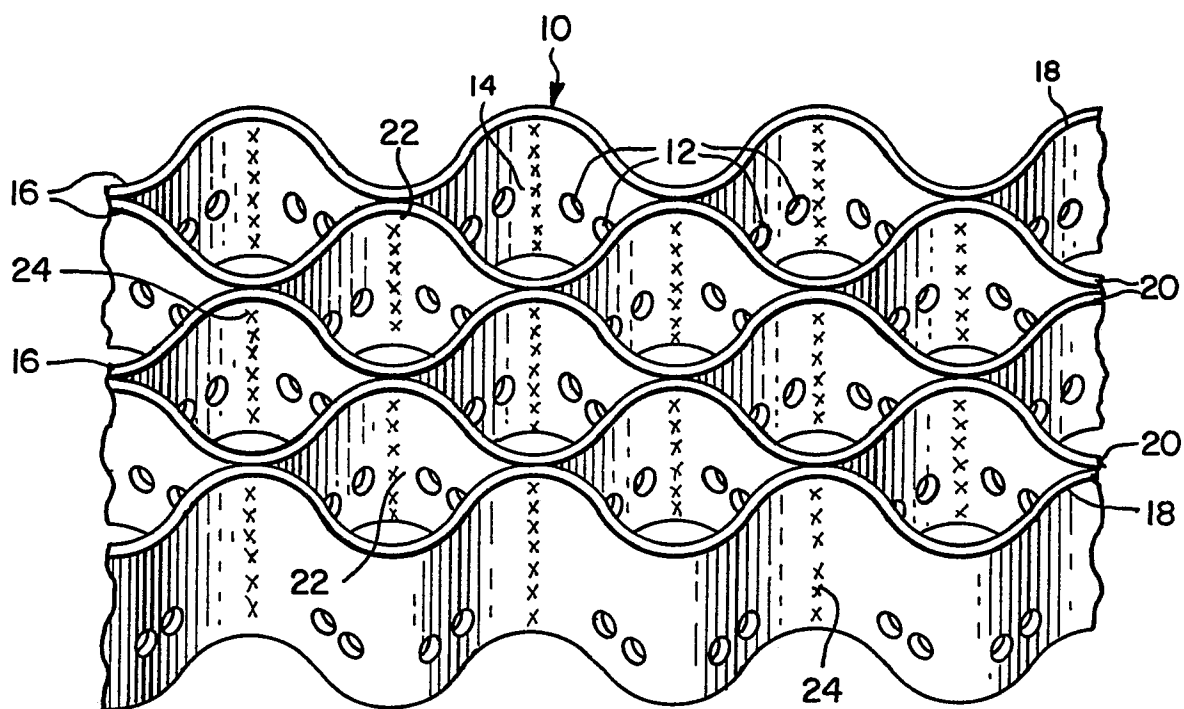


FIG. 1

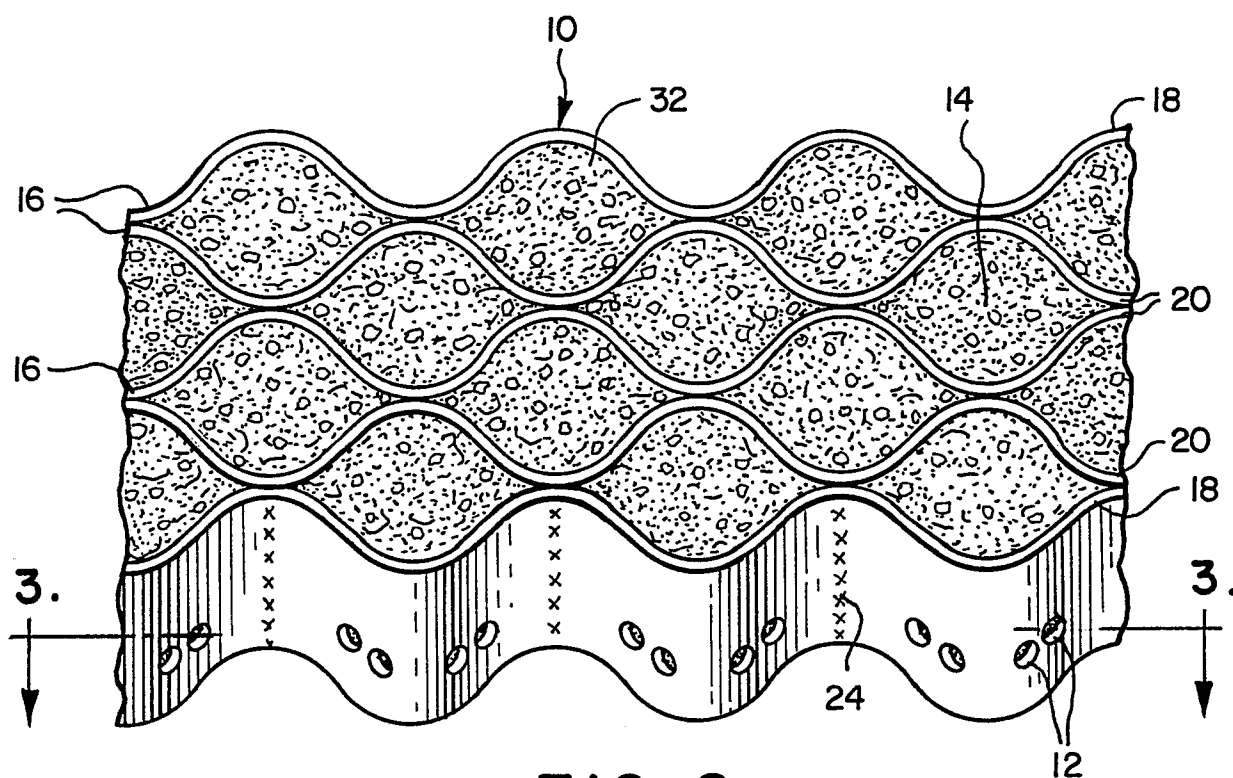


FIG. 2

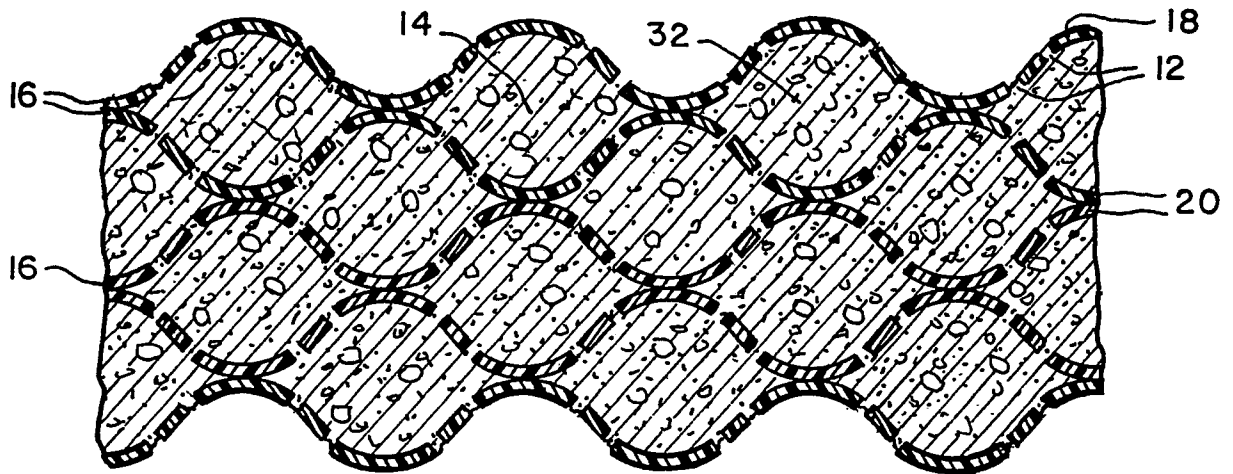


FIG. 3

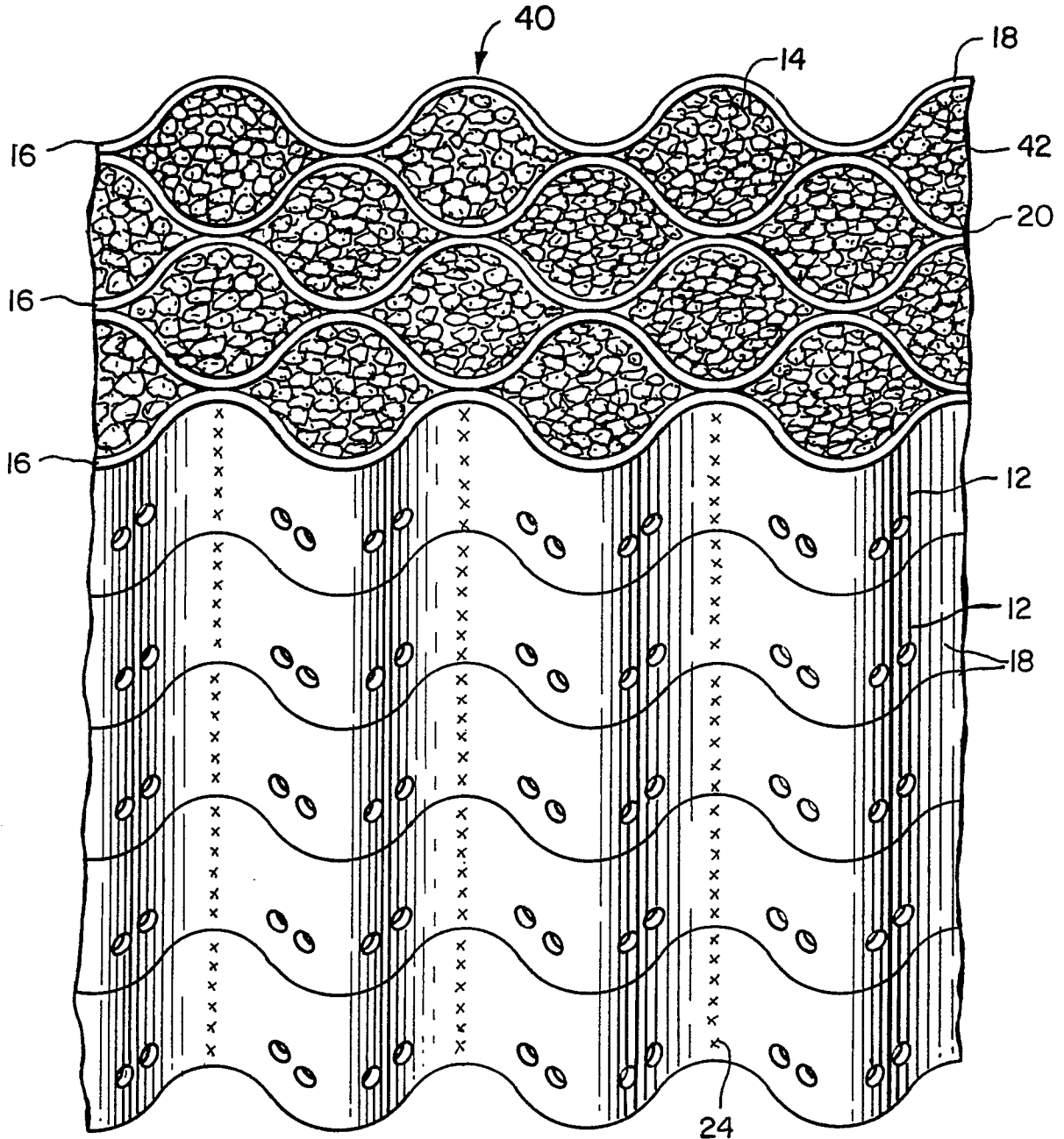


FIG. 4

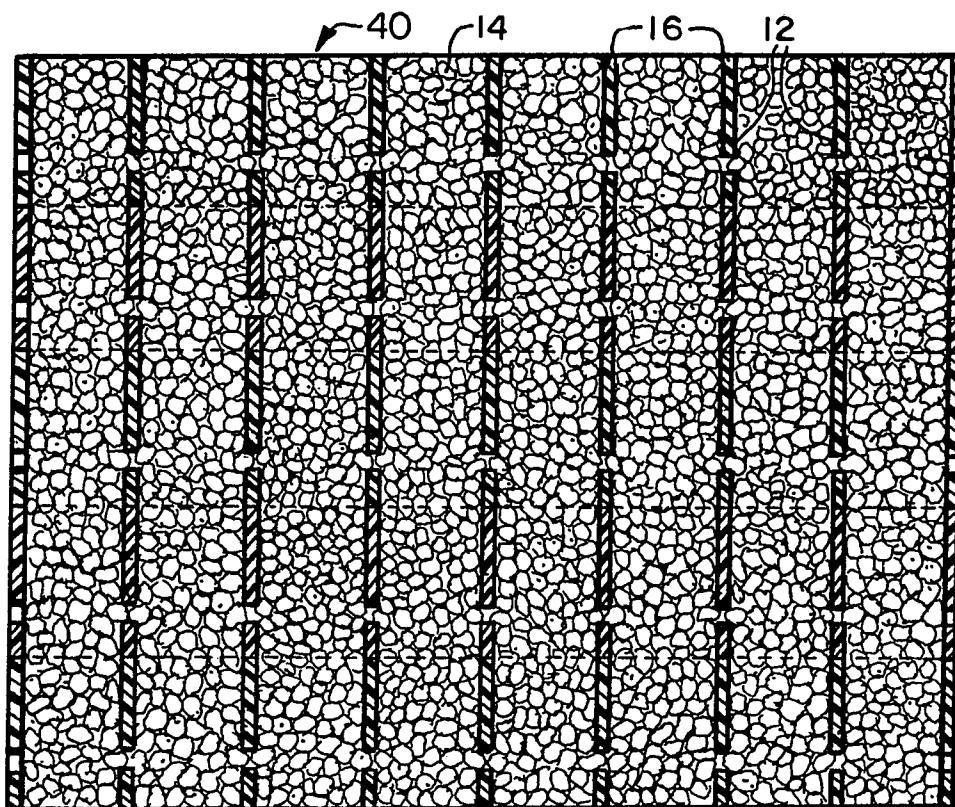


FIG. 5

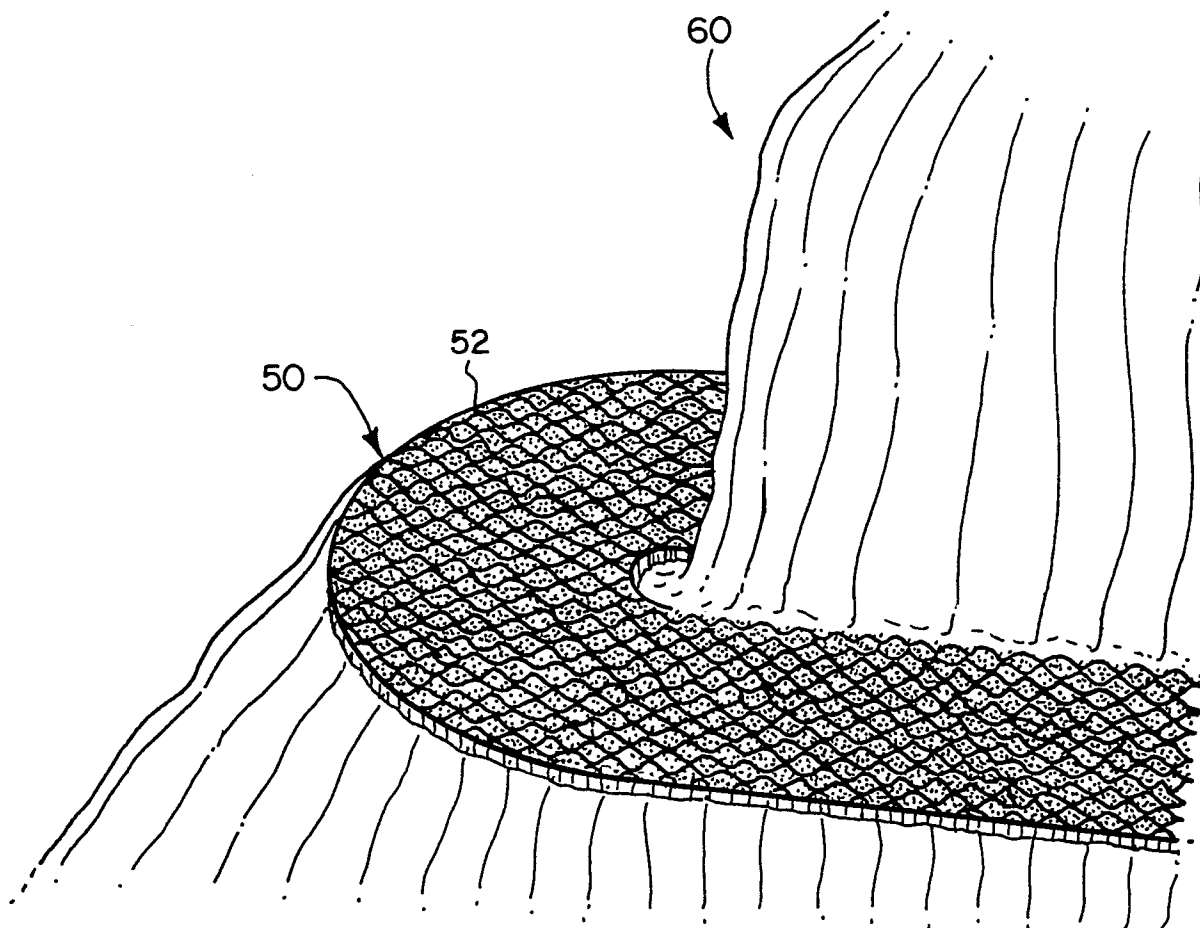


FIG. 6

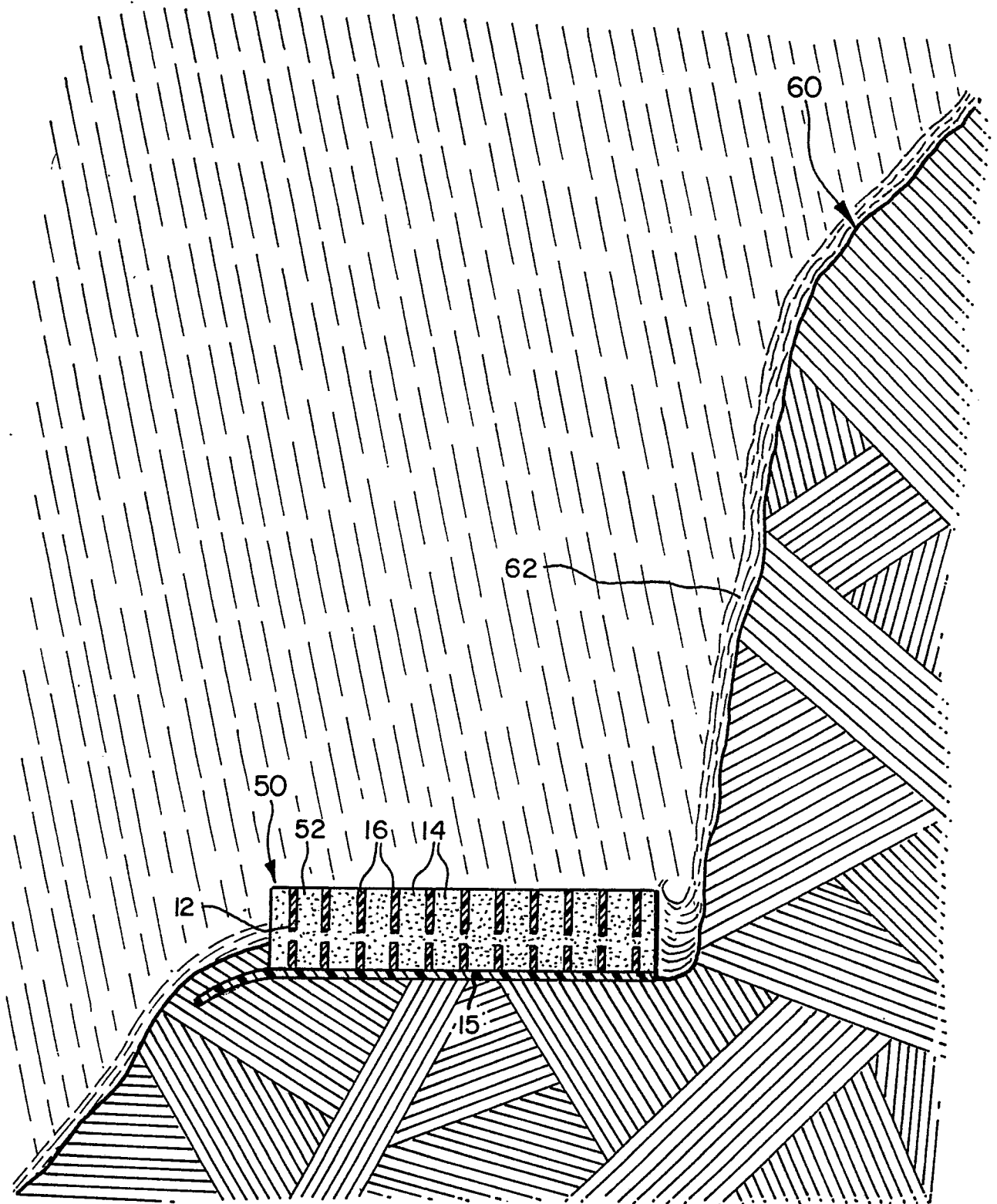
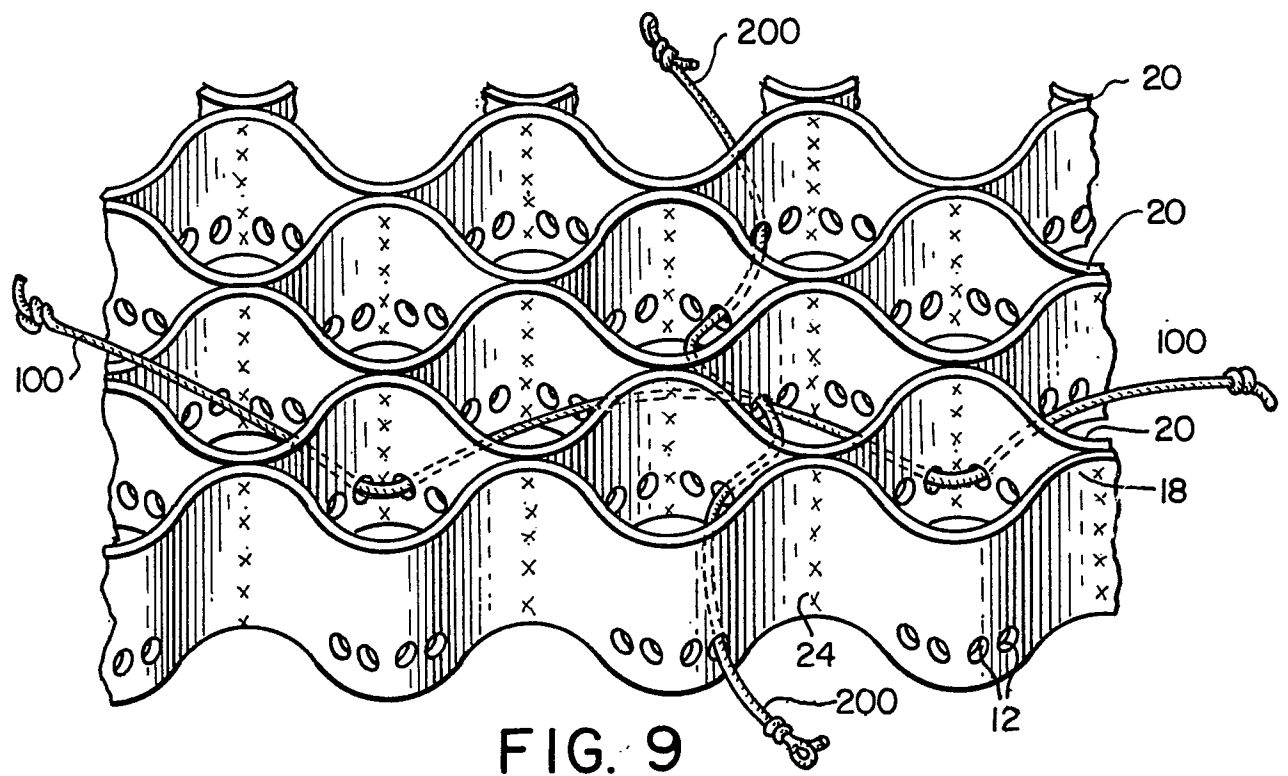
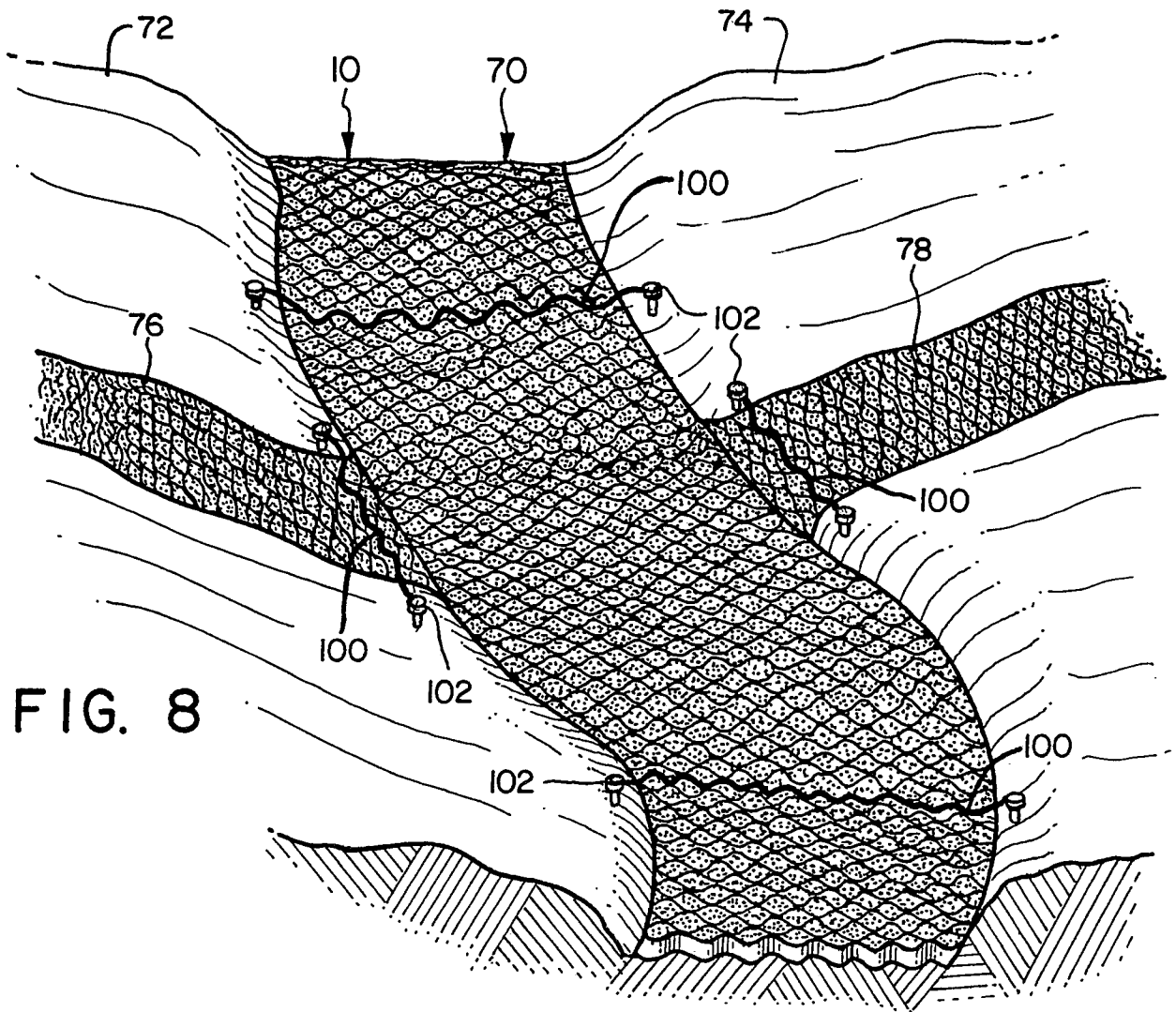


FIG. 7





DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y	US-A-4 797 026 (WEBSTER) * Column 1, line 58 - column 2, line 12; column 3, line 17 - column 4, line 4; column 4, lines 30-64; figures 1-6; claims 1-4 *	1-3,8, 13,17- 20,22, 23,25- 27	E 02 D 17/20
Y	DE-U-8 526 479 (HOLZBAUER) * Page 4, lines 14-30; page 5, lines 21-36; page 7, line 29 - page 8, line 11; claims 1,2; figures 1,2 *	1-3,8, 13,17- 20,22, 23,25- 27	
A		4-7,15, 16	
A	WO-A-8 807 107 (JOHNSON) * Page 1, lines 4-11; page 21, lines 1-19; page 24, line 23 - page 25, line 10; claims 1,12; figures 4,10 *	8,9,10, 21,24	
A	GB-A- 367 256 (MIOZZI) * Whole document *	1-8,11, 15,16	TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			E 02 D E 01 C A 01 G
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 17-04-1990	Examiner BELLINGACCI F.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			