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(54) **DRAINED BARRIER**

DRAINAGESPERRE

BARRIERE DRAINEE

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(73) Proprietor: **ABG Limited  
Meltham HD9 4DS (GB)**

(72) Inventor: **BAMFORTH, Alan  
Holmfirth HD9 4DZ (GB)**

(74) Representative: **Chalk, Anthony John et al  
Harrison Goddard Foote  
Saviour House  
9 St Saviourgate  
York, YO1 8NQ (GB)**

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## Description

### Field of the Invention

**[0001]** The present invention relates to gas proofing, waterproofing and other liquid proofing, and sealing generally. Specifically, the invention is concerned with a material that both provides a barrier and facilitates drainage.

### Background to the Invention

**[0002]** There are many applications, such as landfill containment and capping, rail track, roads, tunnels, roofing, and various other structures, where it is necessary for architects or engineers to utilise geomembranes or other types of waterproofing barriers as an impermeable or semi permeable layer for waterproofing or containment of liquids, gases or solids. These various forms of barrier materials are manufactured from many different types of materials and are produced in discrete widths. The barrier materials are commonly supplied on rolls of suitable length for transport and installation.

**[0003]** In order to form large areas of regular or irregular shape, several rolls or parts of rolls of the barrier materials are joined together, at any angle, on site by means of any of several techniques using, for example, adhesive tape, extrusion, welding, heating, ultrasonics, and the like. Sometimes it is convenient to prefabricate the barrier material into larger panels before it is delivered or utilised on site. When a completely impermeable barrier is required, it is essential that the joints, whether site formed or factory formed, are also impermeable. In this regard, it is possible to inspect the integrity of the joints by means of any of several methods, including vacuum, spark, air pressure or current detection.

**[0004]** The degree of impermeability of the barrier material depends, in the first instance, on its composition and the quality of the installation. In addition, it is also dependent on the pressure head or hydrostatic head on either side of the barrier material. Thus, the greater the pressure which is applied, the more likely it is that the gas, liquid or solid will pass through the barrier. Thus, the control or reduction of the pressure head or hydrostatic head is of great importance.

**[0005]** In some applications, the escape of gas, liquid or solids through the barrier material is anticipated and a void is provided which acts as a leak detection layer or escape route alongside the barrier layer.

**[0006]** Barrier materials of the type described may either be used alone, or in conjunction with at least one of a geotextile, which provides protection, or a geocomposite drain, which facilitates removal of liquid and/or gas, and allows for control of the hydrostatic head or pressure head on the barrier material. The individual layers of barrier material, geotextile and/or geocomposite drain are each installed in separate operations.

**[0007]** The drainage layer may consist of any of a number of different forms, but generally has a geonet or

cusped core structure. In some applications, such as landfill containment where there is an additional requirement for stability of all of the layers on steep slopes, the barrier material preferably comprises a textured surface on one or both sides, which provides increased friction (shear strength) with an adjacent layer. With the exception of the smooth roll edges, which are manufactured without texture, the textured barrier material cannot be joined together to form impermeable joints by use of a hot air/wedge welder, or by means of ultrasonics, unless the texture is first removed by grinding. Consequently, there are difficulties in providing large areas of the material.

**[0008]** An alternative arrangement which was developed some time ago for several applications comprises the bonding of the protective geotextile to the geomembrane or waterproofing barrier material before delivery to site, thereby eliminating the cost and time of a separate installation, as well as increasing the shear strength between layers, even with smooth geomembrane or waterproofing barrier materials. Bonding of the geotextile to the barrier material is omitted along the roll edges in order to enable the joining of the individual rolls into larger areas by any of the known methods. However, it is not possible to form impermeable joints other than at the roll edges in view of the bond between the geotextile and the geomembrane barrier.

**[0009]** Further developments have facilitated the bonding of several layers of geotextile(s) and/or geocomposites drain(s) with geomembrane(s) to create a multi layered system. Again, however, it is not possible to form impermeable joints other than at the roll edges in view of the bond between the geotextile and the geomembrane barrier.

**[0010]** A still further development for structural and landfill applications is that of a geomembrane or waterproofing barrier material with solid projections of various shapes on one or both sides. Typically, said material comprises a thermoplastic material, since such materials readily facilitate formation of the projections. This material combines the functions of barrier and drainage provision when used in conjunction with a geotextile filter or separator that is laid separately over the projections on at least one side of the material. The geomembrane or waterproofing material is manufactured without projections along the roll edges so that it is possible to join individual rolls together to form larger areas. However, it is not possible to join the rolls to form impermeable joints at any major angle other than parallel or perpendicular to the roll edges, or at any point other than at the roll edges, without preparatory grinding to remove the projections.

**[0011]** An alternative development has been the use of drainage composites consisting of an impermeable cusped core as a form of barrier, combined with a geotextile filter/separator. Such impermeable cusped geocomposite drains are manufactured in relatively narrow widths between 1 and 2 metres. Larger widths have been

created by welding several smaller widths together before delivery to site but such welds are not fully impermeable and may only be effected in a direction parallel to the roll length. The major function of these materials has been in achieving drainage, rather than acting as a geomembrane or waterproof barrier. Thus, in order to cover large areas on site, the rolls are simply overlapped with or without tape and, on occasions, the design of the cusps is such that these may be interlocked like press studs. It has not, according to the prior art, been possible to join the rolls on site to form impermeable joints.

**[0012]** In other prior art, US-A-5788413 teaches a water and oil impermeable geosynthetic clay liner which is formed by supporting a layer of liquid swellable material such as bentonite on an impermeable plastic layer. Integrally formed protrusions extend from one surface of the plastic layer to support a permeable plastic cover layer which confines the bentonite clay layer and is heat sealed to the protrusions.

**[0013]** WO-A-88/06929 discloses a bed structure for deposition of refuse and other waste materials which comprises a pair of vertically spaced upper and lower liners or membranes and an intermediate layer of porous material arranged between the liners. Electrical moisture detecting means are positioned between the liners. Since the intermediate layer is normally isolated from percolate contained in the refuse or waste materials and from ground water, the moisture detecting means may detect small leakages in the upper or lower liner or membrane through which percolate or ground water may flow into the intermediate layer.

**[0014]** It would be of great benefit in all applications, but especially landfill containment and capping where very large areas of irregular shape are often to be covered, for the geomembrane or waterproofing barrier material, drainage component and textile(s) to be combined in such a way that joints can be formed or sealed on site at any angle with total integrity of the barriers and/or drainage functions. Furthermore, it would be of great economic benefit if, in addition to the above, the function of the barrier and drainage component were to be combined into one layer. In addition, significant advantages would be associated with a system wherein the geotextile component was bonded or attached in such a way that it could be peeled away easily by hand or machine but wherein the interface in the plane of the geotextile to the adjacent component, which typically comprises the the geomembrane/waterproofing barrier material/drainage component, had high friction and/or shear strength. Such a system does not exist according to prior art, but it is a system having this advantageous feature, together with the other desirable features herein described, that the present invention seeks to provide.

**[0015]** As previously discussed, the preformed barrier materials of the prior art typically comprise a solid plastic layer on which are disposed plastic projections or textures which are designed for friction, or to facilitate a flow of liquid and/or gas. However, these materials cannot be

joined to form impermeable joints at any angle other than perpendicular or parallel to the roll length without prior preparation. However, the present inventor has shown that by providing a material in accordance with the present invention, the said material can be adapted to fulfil both the barrier and drainage function and, optionally, may comprise at least one geotextile that can be peeled away easily but has good interface shear strength and/or friction, and is firmly but releasably attached, wherein the said material may be welded in various dispositions other than the edge-to-edge disposition disclosed in the prior art, whilst still maintaining the integrity of the drainage and/or barrier functions.

## 15 Statements of Invention

**[0016]** Thus, according to the first aspect of the present invention, there is provided a material for use in waterproofing or containment of liquids, gases or solids, said material comprising a layer which comprises an impermeable or a semi permeable barrier and is adapted to facilitate drainage, wherein said material comprises a geomembrane or waterproofing barrier material comprising a plurality of voids which facilitates drainage, said plurality of voids being provided by means of a layer which comprises a cusped layer, said cusped layer comprising a plurality of cusps, characterised in that said cusps are adapted so as to facilitate the joining of the edges or cusped parts of said material to the cusped parts of said material at any angle, said cusps having a shape and being located in a position on said material so as to facilitate said joining.

**[0017]** Said plurality of cusps comprises a plurality of indentations on one side of the layer. Said cusps may be cylindrical, frustoconical, truncated tetrahedral or any hollow shape. Said indentations appear as protrusions on the opposite side of the said layer.

**[0018]** The cusps may be arranged to project as protrusions on one side of the plane of the said layer or, optionally, can be arranged such that indentations and protrusions are observed on both sides of the said layer.

**[0019]** Generally, the cusps protrude from the surface of said layer to a distance of between 1 mm and 15 mm.

**[0020]** The present invention envisages situations wherein the edges or cusped parts of a sample of the material of the invention may be joined to the cusped parts of the same sample of said material. Preferably, however, the edges or cusped parts of a sample of the material are joined to the cusped parts of at least one other sample of said material.

**[0021]** According to a preferred embodiment of the first aspect of the invention, the material of the invention comprises cusps and other additional features adapted so as to facilitate the joining of the edges or cusped parts of the said material to the cusped parts of the said material at any angle, said cusps and other additional features having a shape and being located in a position on said material so as to facilitate said joining. Said other addi-

tional features may comprise, for example, small ridges, grooves or projections.

**[0022]** The material according to the first aspect of the invention preferably comprises a plastics material, preferably a thermoplastic or thermoset plastics material, most preferably a polyolefin such as polyethylene or polypropylene.

**[0023]** Typically, the weight of the cusped layer is in the range of from 300 to 3000 g/m<sup>2</sup> of material.

**[0024]** Said material is capable of being joined at its edges to its other edges or to a separate geomembrane/waterproofing material in a manner that provides continuity and allows for the formation of an effective barrier and drainage facility.

**[0025]** Joins between samples of material according to the first aspect of the invention may be formed by welding, extrusion, heating, application of tape or adhesive, ultrasonics, and the like. Preferably, however, said joins are formed by the action of a hot air/wedge welding machine. Most preferably, said joins can be formed by means of a twin weld comprising a test channel by means of which the integrity of the joins can be determined.

**[0026]** In a particularly preferred embodiment of the first aspect of the invention, the material according to the invention additionally comprises at least one geotextile.

**[0027]** Said geotextile is releasably attached to said material. Said releasable attachment is preferably achieved by means of an adhesive. Preferred adhesives in this context include, for example, hot melts of EVA, rubber or polyolefins.

**[0028]** Alternatively, releasable attachment of said geotextile to said material may be achieved by means of a material of similar chemical characteristics to the material of the invention, such that remaining material on the material of the invention after release does not impair the joining of the said materials.

**[0029]** Further alternatives for achieving the releasable attachment of the material according to the first aspect of the invention to said geotextile include the use of flame bonding, techniques, by the insertion of pins, pegs or staples at various locations across the surface of the said layer, said pins, pegs or staples being adapted to allow said geotextile to be removed from said layer by hand or by application of moderate mechanical force, or by the incorporation of projections from the top of some or all of the cusps in a cusped material, said projections being adapted to engage the said geotextile, thereby achieving good shear strength/friction in the plane of said material, whilst allowing for removal of geotextile from said engagement by hand or by application of moderate mechanical force. Preferably, in the final embodiment, said projections are adapted such that the geotextile, after removal, re-engages with said projections to achieve shear strength/friction in the plane of said material.

**[0030]** According to a second aspect of the present invention, there is provided a method for the formation of a barrier material, said method comprising:

- (a) providing a plurality of samples of material according to the first aspect of the invention;
- (b) arranging said samples adjacent each other in a predetermined formation such that said materials are in contact with each other in certain locations; and
- (c) forming said samples into a single barrier material by the formation of joins at said locations.

**[0031]** Preferably, the formation of joins at the stated locations is carried out by means of welding, extrusion, heating, application of tape or adhesive, ultrasonics, and the like. Most preferably, however, said joins are formed by the action of a hot air/wedge welding machine. Said joins may be formed by means of a twin weld comprising a test channel by means of which the integrity of the joins can be determined.

**[0032]** Preferably, the method according to the second aspect of invention provides a barrier material wherein the welds are formed with cuspsations, grooves or ridges such that the drainage is maintained across and/or along the join.

#### Description of the Invention

**[0033]** The combination of barrier and drainage features provided by the material according to the first aspect of the invention serves to reduce or control the pressure head or hydrostatic head on the said material, such that the transmission of gas, liquids or solids from one side of the said material to the opposite side of the material is greatly reduced in comparison to the effect achieved with a flat geomembrane or waterproofing barrier formed from the same material. Alternatively, the equivalent effect may be achieved with material of the invention which is thinner than a comparable flat geomembrane or waterproofing barrier, since the material of the invention can provide the same rate of transmission of gas, liquid or solid from one side of the material to the opposite side, as may be achieved with a significantly thicker flat barrier.

**[0034]** The combination of a barrier and a plurality of voids provided by the material of the invention additionally serves to provide space above or below the barrier in which any leakage of gas, liquid or solid through the barrier may be identified, isolated and, if necessary, removed.

**[0035]** Optionally, the cusped layer may be formed with flat areas along its edges, wherein said flat areas do not comprise cusps. Alternatively said layer may comprise cusps to the very edges of the layer.

**[0036]** The shape of the cusps which may be comprised in the material according to the first aspect of the invention is adapted such that the said cusps deform readily at elevated temperatures which are generally created by the method of joining, which preferably involves the application of heat or ultrasonic waves. Thus, an essentially flat layer is formed in the region of joining, such that a join may readily be formed. This flattening of the

cusps may be performed prior to, or at the same time as, the actual joining process.

**[0037]** The shape and arrangement of the said cusps is such that the cusps comprised in one sample of the material according to the invention may engage with the cusps comprised in another sample of the material according to the invention, thereby securing the separate samples of material relative to each other such that no slippage occurs during the joining process. Furthermore, other additional features, such as small ridges, grooves or projections, which may be comprised in the material according to the invention are adapted to engage with each other in similar fashion so as to prevent slippage from occurring during the joining process.

**[0038]** In a preferred embodiment of the method according to the second aspect of the invention, the welded area is formed into cusped, grooved or ridged profile by at least one shaped pressure roller or foot whilst the material in the weld is deformable. Preferably, the method utilises a hot air wedge welding machine with at least one roller shaped to form a cusped profile or ridges or grooves. Additionally, it is preferred that the at least one roller provides the driving force to propel the welding machine.

**[0039]** In an alternative embodiment, the method requires a welding machine which comprises a set of rollers shaped to form the cusped profile, ridges or grooves and a separate set of driving rollers to propel the welding machine. The said driving rollers operate outside of the weld, such that there is no shear stress on the weld area due to the propulsion of the welding machine.

**[0040]** In a particularly preferred embodiment of the second aspect of the invention, the method utilises a welding machine adapted so as to automatically separate any geotextile that is releasably attached to the material according to the first aspect of the invention, maintain said geotextile in a location clear of the welding zone, and additionally re-attach said geotextile to the material of the invention after the welding process has been completed.

**[0041]** The preferred welding method comprises arranging one or more pieces of the said layer to overlap each other in a uniform manner. The overlap is typically 20-600 mm, more preferably 30-200 mm. The welding machine then applies heat and pressure whilst gripping the layers and either being propelled, or propelling itself, along.

**[0042]** In an alternative embodiment of the method of the second aspect of the invention, a third sample of material according to the first aspect of the invention is introduced alongside two other pieces of said material such that there exists an overlap, typically 20-600 mm, more preferably 30-200 mm, onto each piece of said layer. The welding machine applies heat and pressure to both sides whilst gripping all three layers and either being propelled, or propelling itself, along.

**[0043]** The material and method according to the present invention find particular application in the sealing

of landfill sites.

## Description of the Drawings

**[0044]** The present invention will now be illustrated, though without limitation, by reference to the accompanying drawings, wherein:

Figures 1(a)-1(d) show cross-sectional views of materials according to the first aspect of the invention; and

Figures 2(a)-2(d) show cross-sectional views of barrier materials obtained by the method of the second aspect of the invention.

**[0045]** Looking first at Figure 1(a), there is seen a material (1) according to the first aspect of the invention wherein said material is cusped on one side only and comprises cusps (2).

**[0046]** Figure 1 (b) shows a material (3) according to the first aspect of the invention wherein said material comprises cusps (4) on one side of the material only and additionally comprises a layer of geotextile (5) on the cusped surface.

**[0047]** Figure 1 (c) illustrates a material (6) according to the first aspect of the invention wherein said material comprises cusps (7, 8) on both sides of the material and additionally comprises a layer of geotextile (9) on one of the cusped surfaces.

**[0048]** Figure 1(d) shows a material (10) according to the first aspect of the invention wherein said material comprises cusps (11, 12) on both sides of the material and additionally comprises layers of geotextile (13, 14) on both of the cusped, surfaces.

**[0049]** Turning now to Figure 2(a), there is shown a barrier material obtained by the method of the second aspect of the invention, wherein said barrier material comprises a first sample (15) of a material according to the first aspect of the invention, said sample comprising cusps (16) and a flat section (17), and a second sample (18) of a material according to the first aspect of the invention, said sample comprising cusps (19), said barrier material being obtained by the formation of an impermeable joint (20) between said flat section (17) of said first sample (15) and said cusps (19) of said second sample (18).

**[0050]** Figure 2(b) shows a barrier material obtained by the method of the second aspect of the invention, wherein said barrier material comprises a first sample (21) of a material according to the first aspect of the invention, said sample comprising cusps (22), and a second sample (23) of a material according to the first aspect of the invention, said sample comprising cusps (24), said barrier material being obtained by the formation of an impermeable joint (25) between said cusps (22) of said first sample (21) and said cusps (24) of said second sample (23).

**[0051]** In Figure 2(c) there is seen a barrier material obtained by the method of the second aspect of the invention, wherein said barrier material comprises a first sample (26) of a material according to the first aspect of the invention, said sample comprising cusps (27), and a second sample (28) of a material according to the first aspect of the invention, said sample comprising cusps (29), said barrier material being obtained by the formation of an impermeable joint (30) between said first sample (26) and said second sample (27), wherein said cusps deform at elevated temperature such that an essentially flat layer (31) comprising a twin weld (32, 33) and a test channel (34) is formed in the region of joining.

**[0052]** Figure 2(d) illustrates a barrier material obtained by the method of the second aspect of the invention, wherein said barrier material comprises a first sample (35) of a material according to the first aspect of the invention, said sample comprising cusps (36), and a second sample (37) of a material according to the first aspect of the invention, said sample comprising cusps (38), said barrier material being obtained by the formation of an impermeable joint (39) between said first sample (35) and said second sample (37), wherein the welded area (40) is formed into a cusped profile (41) comprising welds (42) by the action of at least one shaped pressure roller or foot whilst the material in the weld is deformable.

## Claims

1. A material (1, 3, 6, 10, 15, 18, 21, 23, 26, 28, 35, 37) for use in waterproofing or containment of liquids, gases or solids, said material comprising a layer which comprises an impermeable or a semi permeable barrier and is adapted to facilitate drainage, wherein said material comprises a geomembrane or waterproofing barrier material comprising a plurality of voids which facilitates drainage, said plurality of voids being provided by means of a layer which comprises a cusped layer, said cusped layer comprising a plurality of cusps (2, 4, 7, 8, 11, 12, 16, 19, 22, 24, 27, 29, 36, 38), **characterised in that** said cusps are adapted so as to facilitate the joining of the edges or cusped parts of said material to the cusped parts of said material at any angle, said cusps having a shape and being located in a position on said material so as to facilitate said joining.
2. A material (1, 3, 6, 10, 15, 18, 21, 23, 26, 28, 35, 37) as claimed in claim 1 wherein said cusps (2, 4, 7, 8, 11, 12, 16, 19, 22, 24, 27, 29, 36, 38) are cylindrical, frustoconical, truncated tetrahedral or any hollow shape.
3. A material (1, 3, 15, 18, 21, 23, 26, 28, 35, 37) as claimed in claim 1 or 2 wherein said cusps (2, 4, 16, 19, 22, 24, 27, 29, 36, 38) are arranged to project as protrusions on one side of the plane of the said layer.
4. A material (6, 10) as claimed in claim 1 or 2 wherein said cusps (7, 8, 11, 12) are arranged such that indentations and protrusions are observed on both sides of the said layer.
5. A material (1, 3, 6, 10, 15, 18, 21, 23, 26, 28, 35, 37) as claimed in any one of claims 1 to 4 wherein said cusps (2, 4, 7, 8, 11, 12, 16, 19, 22, 24, 27, 29, 36, 38) protrude from the surface of said layer to a distance of between 1 mm and 15 mm.
6. A material (1, 3, 6, 10, 15, 18, 21, 23, 26, 28, 35, 37) as claimed in any preceding claim wherein the cusped layer is formed with flat areas along its edges, wherein said flat areas do not comprise cusps.
7. A material as claimed in any one of claims 1 to 5 wherein the cusped layer comprises cusps to the edges of the layer.
8. A material as claimed in any one of claims 1 to 6 wherein the flat edges or cusped parts of a sample of said material are joined to the cusped parts of the same sample of said material.
9. A material (15, 18, 21, 23, 35, 37) as claimed in any one of claims 1 to 7 wherein the flat edges (17) or cusped parts (22, 36) of one sample of said material are joined to the cusped parts (19, 29, 38) of at least one other sample of said material.
10. A material (1, 3, 6, 10, 15, 18, 21, 23, 26, 28, 35, 37) as claimed in any preceding claim which comprises cusps (2, 4, 7, 8, 11, 12, 16, 19, 22, 24, 27, 29, 36, 38) and additional features adapted so as to facilitate the joining of the edges or cusped parts of said material to the cusped parts of said material at any angle, said cusps and additional features having a shape and being located in a position on said material so as to facilitate said joining.
11. A material (1, 3, 6, 10, 15, 18, 21, 23, 26, 28, 35, 37) as claimed in claim 10 wherein said additional features comprise small ridges, grooves or projections.
12. A material (1, 3, 6, 10, 15, 18, 21, 23, 26, 28, 35, 37) as claimed in any preceding claim which comprises a plastics material, preferably a thermoplastic or thermoset plastics material.
13. A material (1, 3, 6, 10, 15, 18, 21, 23, 26, 28, 35, 37) as claimed in claim 12 which comprises a polyolefin, preferably polyethylene or polypropylene.
14. A material (3, 6, 10) as claimed in any preceding claim wherein said material additionally comprises at least one geotextile (5, 9, 13, 14) which is preferably releasably attached to said material.

15. A material (3, 6, 10) as claimed in claim 14 wherein said releasable attachment is achieved by means of an adhesive, preferably comprising hot melts of EVA, rubber or polyolefins, or by means of flame bonding techniques, by the insertion of pins, pegs or staples at various locations across the surface of the said layer, or by the incorporation of projections from the top of some or all of the cusps in a cusped material, said projections being adapted to engage the said geotextile (5, 9, 13, 14).
16. A method for the formation of a barrier material, said method comprising:
- (a) providing a plurality of samples of material (1, 3, 6, 10, 15, 18, 21, 23, 26, 28, 35, 37) according to any one of claims 1 to 15;
  - (b) arranging said samples adjacent each other in a predetermined formation such that said materials are in contact with each other in certain locations; and
  - (c) forming said samples into a single barrier material by the formation of joins (20, 25, 30, 39) at said locations.
17. A method as claimed in claim 16 wherein the formation of joins (20, 25, 30, 39) at the stated locations is carried out by means of welding, extrusion, heating, application of tape or adhesive, or ultrasonics.
18. A method as claimed in claim 16 or 17 wherein said joins (20, 25, 30, 39) are formed by the action of a hot air/wedge welding machine.
19. A method as claimed in claim 17 or 18 wherein said joins (20, 25, 30, 39) comprises welds which are formed with cuspatations, grooves or ridges such that the drainage is maintained across and/or along the join.
20. A method as claimed in claim 17, 18 or 19 wherein the welded area is formed into cusped, grooved or ridged profile by at least one shaped pressure roller or foot whilst the material in the weld is deformable.
21. A method as claimed in any one of claims 15 to 20 which utilises a welding machine adapted so as to automatically separate a geotextile (5, 9, 13, 14) that is releasably attached to a material (3, 6, 10), maintain said geotextile in a location clear of the welding zone, and additionally re-attach said geotextile to the material after the welding process has been completed.

#### Patentansprüche

1. Material (1, 3, 6, 10, 15, 18, 21, 23, 26, 28, 35, 37)

zur Verwendung zum Wasserdichtmachen oder Aufnehmen von Flüssigkeiten, Gasen oder Feststoffen, wobei das Material eine Schicht aufweist, die eine impermeable oder semipermeable Barriere umfasst und angepasst ist, um Drainage zu erleichtern, wobei das Material eine Geomembran oder ein wasserdicht machendes Barrierematerial umfasst, das eine Vielzahl von Hohlräumen umfasst, die Drainage erleichtern, wobei die Vielzahl von Hohlräumen mittels einer Schicht bereitgestellt wird, die eine höckerige Schicht umfasst, wobei die höckerige Schicht eine Vielzahl von Höckern (2, 4, 7, 8, 11, 12, 16, 19, 22, 24, 27, 29, 36, 38) aufweist, **dadurch gekennzeichnet, dass** die Höcker angepasst sind, um die Verbindung der Ränder oder höckerigen Teile des Materials mit den höckerigen Teilen des Materials in jedwedem Winkel zu erleichtern, wobei die Höcker eine Form haben und sich in einer Position auf dem Material befinden, um diese Verbindung zu erleichtern.

2. Material (1, 3, 6, 10, 15, 18, 21, 23, 26, 28, 35, 37) nach Anspruch 1, wobei die Höcker (2, 4, 7, 8, 11, 12, 16, 19, 22, 24, 27, 29, 36, 38) zylindrisch, kegelstumpfförmig, tetraederstumpfförmig oder von jedweder Hohlform sind.
3. Material (1, 3, 15, 18, 21, 23, 26, 28, 35, 37) nach Anspruch 1 oder 2, wobei die Höcker (2, 4, 16, 19, 22, 24, 27, 29, 36, 38) so angeordnet sind, dass sie als Ausbuchtungen an einer Seite der Ebene der Schicht herausragen.
4. Material (6, 10) nach Anspruch 1 oder 2, wobei die Höcker (7, 8, 11, 12) so angeordnet sind, dass auf beiden Seiten der Schicht Vertiefungen und Ausbuchtungen beobachtet werden.
5. Material (1, 3, 6, 10, 15, 18, 21, 23, 26, 28, 35, 37) nach einem der Ansprüche 1 bis 4, wobei die Höcker (2, 4, 7, 8, 11, 12, 16, 19, 22, 24, 27, 29, 36, 38) von der Oberfläche der Schicht bis zu einem Abstand zwischen 1 mm und 15 mm herausragen.
6. Material (1, 3, 6, 10, 15, 18, 21, 23, 26, 28, 35, 37) nach einem der vorhergehenden Ansprüche, wobei die höckerige Schicht mit flachen Bereichen an ihren Rändern ausgebildet ist, wobei diese flachen Bereiche keine Höcker aufweisen.
7. Material nach einem der Ansprüche 1 bis 5, wobei die höckerige Schicht Höcker bis zu den Rändern der Schicht aufweist.
8. Material nach einem der Ansprüche 1 bis 6, wobei die flachen Ränder oder höckerigen Teile eines Exemplars des Materials mit den höckerigen Teilen desselben Exemplars des Materials verbunden sind.

9. Material (15, 18, 21, 23, 35, 37) nach einem der Ansprüche 1 bis 7, wobei die flachen Ränder (17) oder höckerigen Teile (22, 36) eines Exemplars dieses Materials mit den höckerigen Teilen (19, 29, 38) von mindestens einem anderen Exemplar des Materials verbunden sind. 5
10. Material (1, 3, 6, 10, 15, 18, 21, 23, 26, 28, 35, 37) nach einem der vorhergehenden Ansprüche, das Höcker (2, 4, 7, 8, 11, 12, 16, 19, 22, 24, 27, 29, 36, 38) und weitere Merkmale aufweist, die angepasst sind, um die Verbindung der Ränder oder höckerigen Teile des Materials mit den höckerigen Teilen des Materials in jedwedem Winkel zu erleichtern, wobei die Höcker und weiteren Merkmale eine Form haben und sich in einer Position auf dem Material befinden, um die Verbindung zu erleichtern. 10
11. Material (1, 3, 6, 10, 15, 18, 21, 23, 26, 28, 35, 37) nach Anspruch 10, wobei die weiteren Merkmale kleine Kämme, Rillen oder Vorsprünge umfassen. 15
12. Material (1, 3, 6, 10, 15, 18, 21, 23, 26, 28, 35, 37) nach einem der vorhergehenden Ansprüche, das ein Kunststoffmaterial umfasst, vorzugsweise ein thermoplastisches oder duroplastisches Kunststoffmaterial. 20
13. Material (1, 3, 6, 10, 15, 18, 21, 23, 26, 28, 35, 37) nach Anspruch 12, das ein Polyolefin umfasst, vorzugsweise Polyethylen oder Polypropylen. 25
14. Material (3, 6, 10) nach einem der vorhergehenden Ansprüche, das zusätzlich mindestens ein Geotextil (5, 9, 13, 14) umfasst, das vorzugsweise lösbar an dem Material befestigt ist. 30
15. Material (3, 6, 10) nach Anspruch 14, bei dem die lösbare Befestigung mittels eines Klebstoffs, der vorzugsweise Heißschmelzen von EVA, Kautschuk oder Polyolefinen umfasst, oder mittels Flammbondierungstechniken, durch Einführen von Stiften, Haken oder Klammern an verschiedenen Positionen entlang der Oberfläche der Schicht oder durch den Einbau von Vorsprüngen an dem Oberteil von einigen oder allen der Höcker in einem höckerigen Material erreicht wird, wobei die Vorsprünge angepasst sind, um mit dem Geotextil (5, 9, 13, 14) in Eingriff zu kommen. 35
16. Verfahren zur Formung eines Barrierematerials, welches folgendes umfasst: 40
- (a) Bereitstellen einer Vielzahl von Exemplaren von Material (1, 3, 6, 10, 15, 18, 21, 23, 26, 28, 35, 37) nach einem der Ansprüche 1 bis 15; 45
- (b) Anordnen der Exemplare nebeneinander in einer festgelegten Formation, so dass sich die Materialien in bestimmten Positionen in Kontakt miteinander befinden, und 50
- (c) Formung der Exemplare zu einem einzigen Barrierematerial durch Formung von Bindungen (20, 25, 30, 39) an den Positionen.
17. Verfahren nach Anspruch 16, wobei die Formung von Bindungen (20, 25, 30, 39) an den angegebenen Positionen mittels Schweißen, Extrusion, Erhitzen, Anwendung von Klebeband oder Klebstoff oder Ultraschall bewirkt wird.
18. Verfahren nach Anspruch 16 oder 17, wobei die Verbindungen (20, 25, 30, 39) durch die Aktion einer Heißluft/Keilschweißmaschine geformt werden.
19. Verfahren nach Anspruch 17 oder 18, wobei die Verbindungen (20, 25, 30, 39) Schweißungen umfassen, die mit Höckern, Rillen oder Kämmen geformt sind, so dass die Drainage über und/oder entlang der Verbindung erhalten bleibt.
20. Verfahren nach Anspruch 17, 18 oder 19, wobei der geschweißte Bereich durch mindestens eine formgestaltete Presswalze oder einen formgestalteten Pressschuh zu höckerigem, gerilltem oder Kämmen aufweisendem Profil geformt wird, während das Material in der Schweißung verformbar ist.
21. Verfahren nach einem der Ansprüche 15 bis 20, das eine Schweißmaschine verwendet, die so angepasst ist, dass sie automatisch ein Geotextil (5, 9, 13, 14) trennt, das lösbar an einem Material (3, 6, 10) befestigt wird, das Geotextil in einer Position außerhalb der Schweißzone hält und des Weiteren das Geotextil wieder an dem Material befestigt, nachdem der Schweißprozess abgeschlossen worden ist.

## Revendications

1. Matériau (1, 3, 6, 10, 15, 18, 21, 23, 26, 28, 35, 37) pour utilisation dans l'imperméabilisation ou le confinement de liquides, de gaz ou de solides, ledit matériau étant composé d'une couche qui contient une barrière imperméable ou semi-imperméable et qui est adaptée pour faciliter le drainage, dans laquelle ledit matériau est constitué d'une géomembrane ou d'un matériau barrière d'imperméabilisation qui comprend une pluralité de vides qui facilitent le drainage, ladite pluralité de vides étant fournie au moyen d'une couche constituée d'une couche festonnée, ladite couche festonnée comprenant une pluralité de festons (2, 4, 7, 8, 11, 12, 16, 19, 22, 24, 27, 29, 36, 38), **caractérisée en ce que** lesdits festons sont adaptés de façon à faciliter l'assemblage des bords ou des parties festonnées dudit matériau selon n'importe quel angle, lesdits festons ayant une forme et

une position sur ledit matériau de façon à faciliter ledit assemblage.

2. Matériau (1, 3, 6, 10, 15, 18, 21, 23, 26, 28, 35, 37) selon la revendication 1, dans lequel lesdits festons (2, 4, 7, 8, 11, 12, 16, 19, 22, 24, 27, 29, 36, 38) sont cylindriques, tronconiques, tronqués de manière tétraédrique ou de toute forme creuse.
3. Matériau (1, 3, 15, 18, 21, 23, 26, 28, 35, 37) selon la revendication 1 ou 2, dans lequel lesdits festons (2, 4, 16, 19, 22, 24, 27, 29, 36, 38) sont disposés de manière à saillir comme des protubérances d'un côté du plan de ladite couche.
4. Matériau (6, 10) selon la revendication 1 ou 2, dans lequel lesdits festons (7, 8, 11, 12) sont disposés de manière à ce que des indentations et des protubérances soient observées des deux côtés de ladite couche.
5. Matériau (1, 3, 6, 10, 15, 18, 21, 23, 26, 28, 35, 37) selon l'une quelconque des revendications 1 à 4, dans lequel lesdits festons (2, 4, 7, 8, 11, 12, 16, 19, 22, 24, 27, 29, 36, 38) saillent de la surface de ladite couche à une distance située entre 1 mm et 15 mm.
6. Matériau (1, 3, 6, 10, 15, 18, 21, 23, 26, 28, 35, 37) selon l'une quelconque des revendications précédentes, dans lequel la couche festonnée est formée de zones plates le long de ses bords, dans laquelle lesdites zones plates ne sont pas constituées de festons.
7. Matériau selon l'une quelconque des revendications 1 à 5, dans lequel la couche festonnée est constituée de festons jusqu'aux bords de la couche.
8. Matériau selon l'une quelconque des revendications 1 à 6, dans lequel les bords plats ou les parties festonnées d'un échantillon dudit matériau sont assemblés aux parties festonnées du même échantillon dudit matériau.
9. Matériau (15, 18, 21, 23, 35, 37) selon l'une quelconque des revendications 1 à 7, dans lequel les bords plats (17) ou les parties festonnées (22, 36) d'un échantillon dudit matériau sont assemblés aux parties festonnées (19, 29, 38) d'au moins un autre échantillon dudit matériau.
10. Matériau (1, 3, 6, 10, 15, 18, 21, 23, 26, 28, 35, 37) selon l'une quelconque des revendications précédentes, lequel comprend des festons (2, 4, 7, 8, 11, 12, 16, 19, 22, 24, 27, 29, 36, 38) et des caractéristiques supplémentaires adaptées de façon à faciliter l'assemblage des bords ou des parties festonnées dudit matériau selon n'importe quel angle, lesdits

festons et lesdites caractéristiques supplémentaires ayant une forme et une position sur ledit matériau de façon à faciliter ledit assemblage.

11. Matériau (1, 3, 6, 10, 15, 18, 21, 23, 26, 28, 35, 37) selon la revendication 10, dans lequel lesdites caractéristiques supplémentaires comprennent de petites stries, rainures ou saillies.
12. Matériau (1, 3, 6, 10, 15, 18, 21, 23, 26, 28, 35, 37) selon l'une quelconque des revendications précédentes, lequel comprend un matériau en plastique, de préférence un matériau thermoplastique ou un matériau en plastique thermodurci.
13. Matériau (1, 3, 6, 10, 15, 18, 21, 23, 26, 28, 35, 37) selon la revendication 12, lequel est constitué d'une polyoléfine, de préférence un polyéthylène ou un polypropylène.
14. Matériau (3, 6, 10) selon l'une quelconque des revendications précédentes, dans lequel ledit matériau est constitué d'au moins un géotextile (5, 9, 13, 14) qui est de préférence fixé de façon amovible audit matériau.
15. Matériau (3, 6, 10) selon la revendication 14, dans lequel ladite fixation amovible est obtenue au moyen d'un adhésif, comprenant de préférence des adhésifs thermofusibles d'EVA, de caoutchouc ou de polyoléfines, ou au moyen de techniques de doublage thermique, par l'insertion de goupilles, de piquets ou d'agrafes à divers endroits à la surface de ladite couche, ou par l'incorporation de saillies à partir du dessus de certains des, ou de tous les, festons dans un matériau festonné, lesdites saillies étant adaptées pour s'engager dans ledit géotextile (5, 9, 13, 14).
16. Procédé pour la formation d'un matériau barrière, ledit procédé consistant à :
  - (a) prévoir une pluralité d'échantillons d'un matériau (1, 3, 6, 10, 15, 18, 21, 23, 26, 28, 35, 37) selon l'une quelconque des revendications 1 à 15 ;
  - (b) disposer lesdits échantillons adjacents les uns aux autres dans une disposition prédéterminée de sorte que lesdits matériaux sont en contact les uns avec les autres à certains endroits ; et
  - (c) former lesdits échantillons en un matériau barrière unique par la formation de lignes de raccord (20, 25, 30, 39) aux dits emplacements.
17. Procédé selon la revendication 16, dans lequel la disposition de lignes de raccords (20, 25, 30, 39) aux emplacements énoncés est réalisée au moyen d'une soudure, d'une extrusion, de chauffage, de l'appli-

cation d'un ruban ou d'un adhésif, ou d'ultrasons.

- 18.** Procédé selon la revendication 16 ou 17, dans lequel lesdites lignes de raccords (20, 25, 30, 39) sont formées par l'action d'une machine de soudage à air chaud/à panne chauffante. 5
- 19.** Procédé selon la revendication 17 ou 18, dans lequel lesdites lignes de raccords (20, 25, 30, 39) sont constituées de soudures qui sont formées avec des festons, des rainures ou des stries de sorte que le drainage est maintenu à travers ou le long de la ligne de raccord. 10
- 20.** Procédé selon la revendication 17, 18 ou 19, dans lequel la région soudée est formée en un profil festonné, rainuré ou strié par au moins un rouleau de pression profilé ou un pied alors que le matériau dans la soudure est déformable. 15
- 21.** Procédé selon l'une quelconque des revendications 15 à 20, lequel utilise une machine à souder adaptée pour séparer automatiquement un géotextile (5, 9, 13, 14) qui est fixé de manière amovible à un matériau (3, 6, 10), maintient ledit géotextile à un emplacement éloigné de la zone de soudure et fixe en outre de nouveau ledit géotextile au matériau après la fin du procédé de soudure. 20 25

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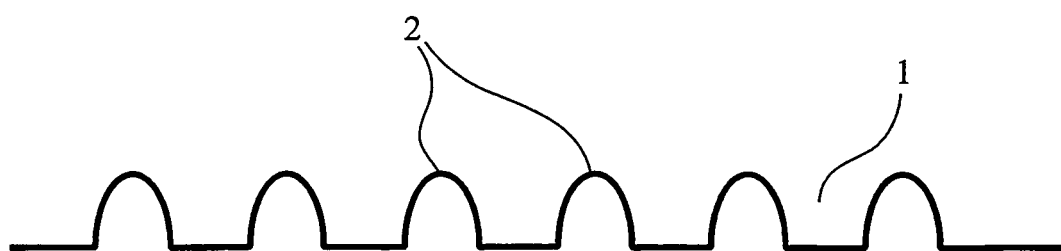


Fig. 1(a)

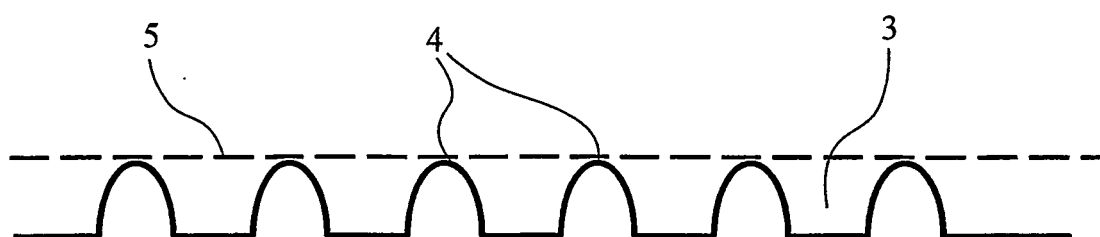


Fig. 1(b)

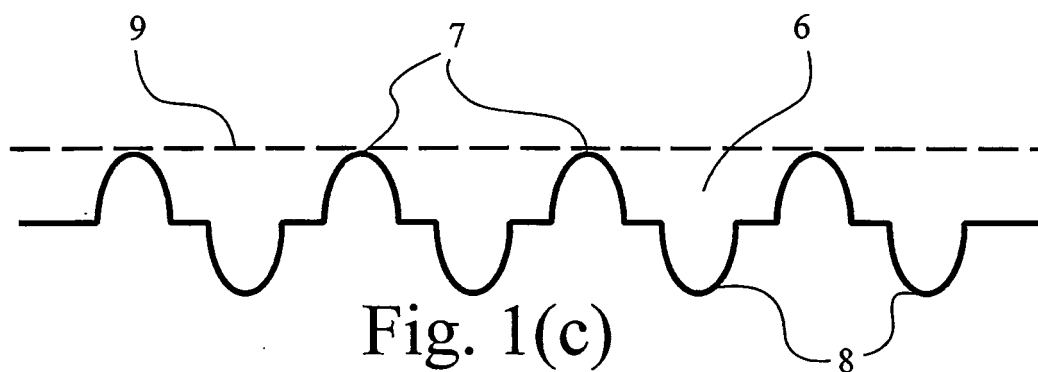


Fig. 1(c)

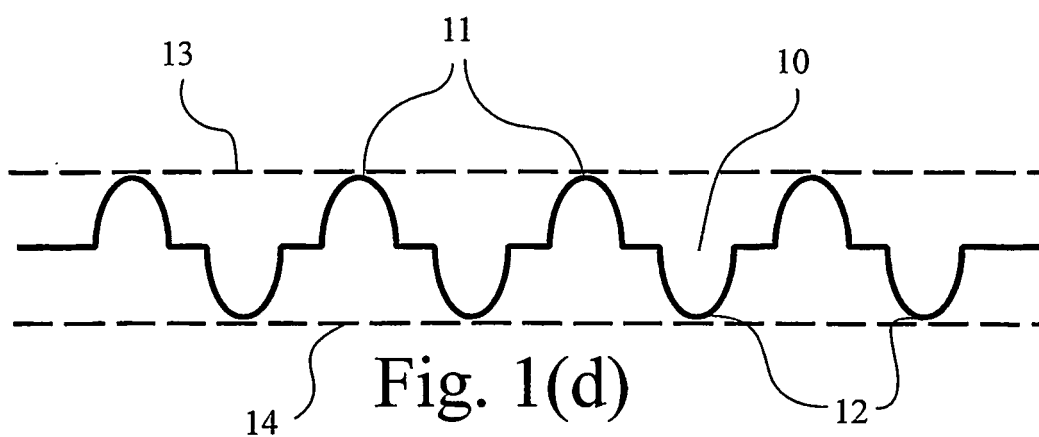
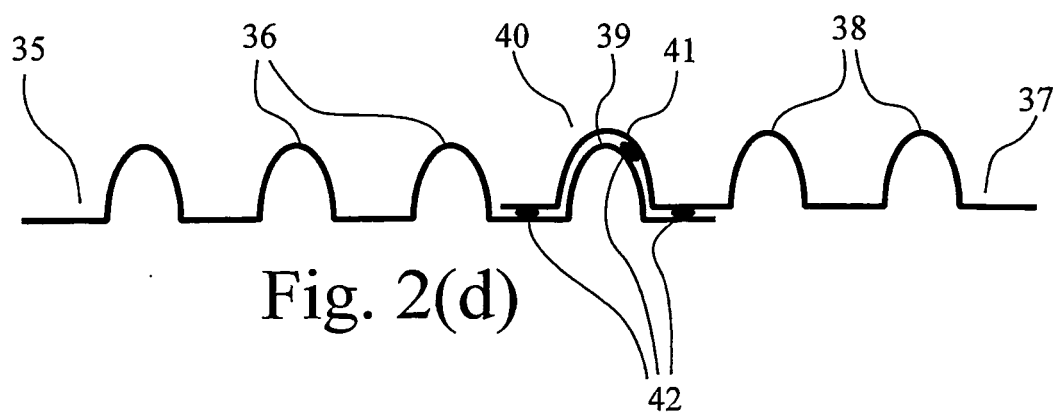
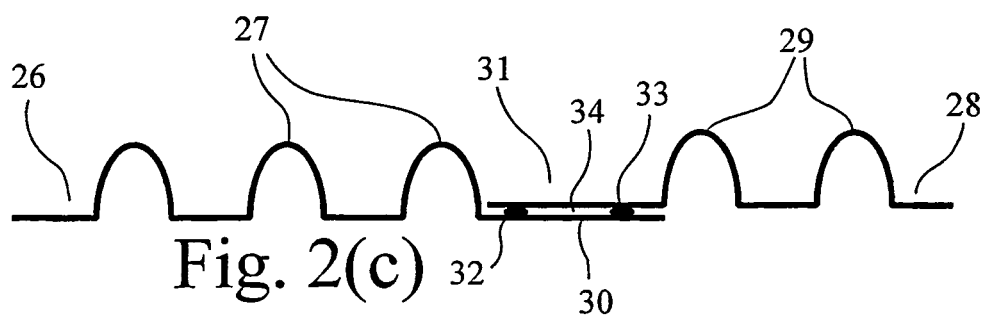
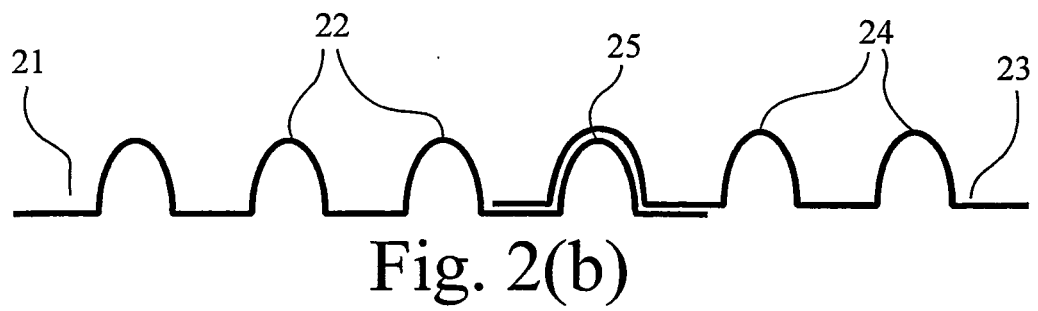
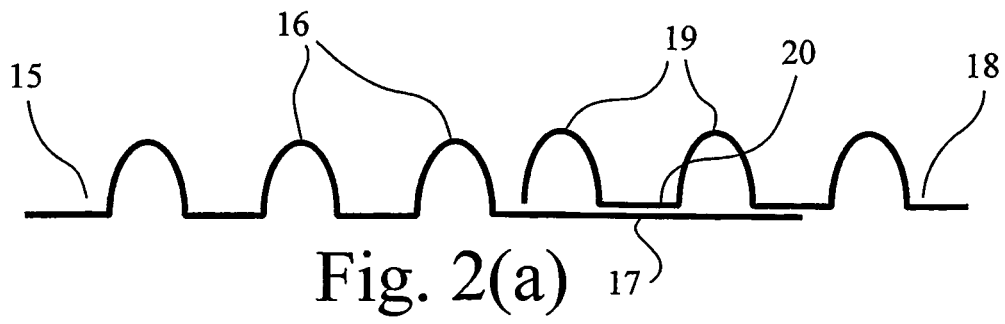


Fig. 1(d)



**REFERENCES CITED IN THE DESCRIPTION**

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