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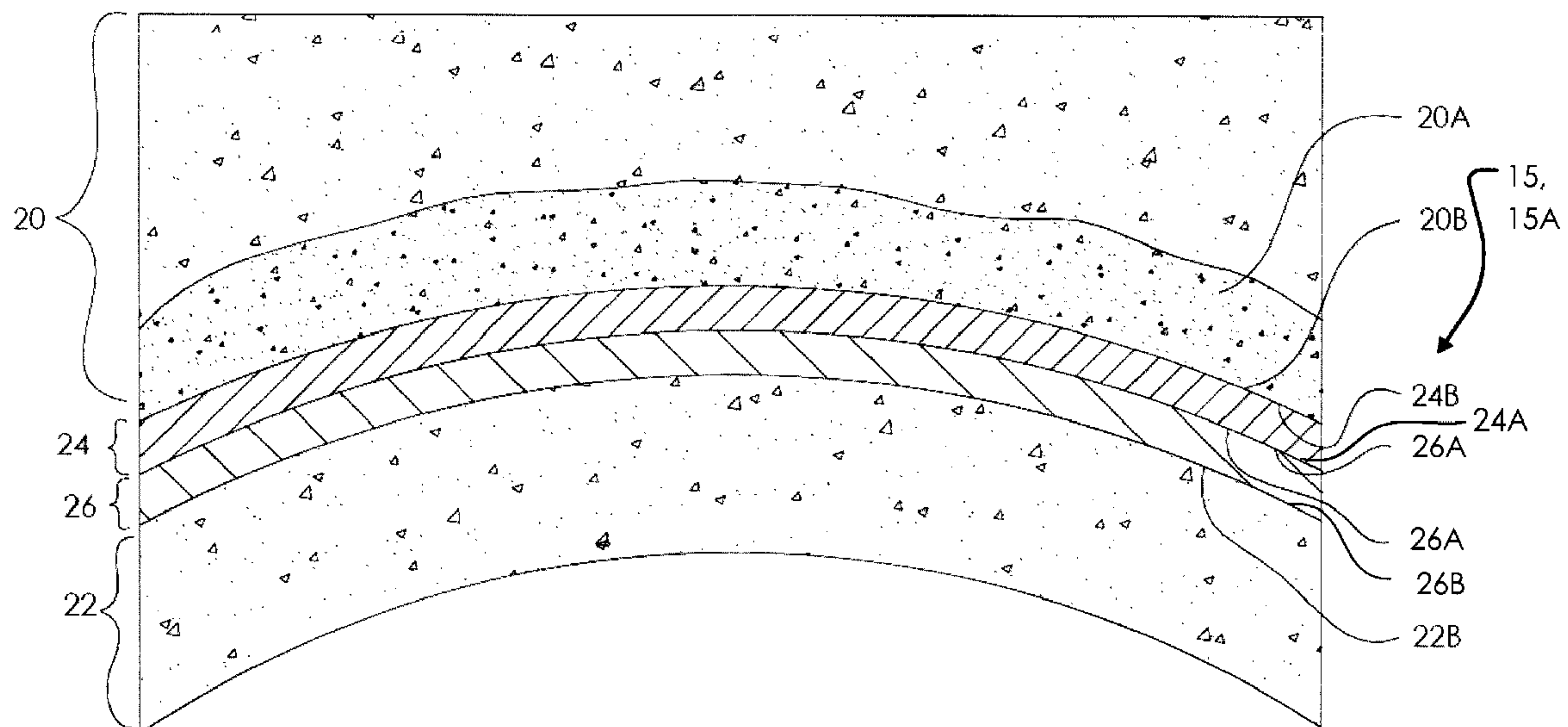
(71) **Demandeur/Applicant:**
CFS CONCRETE FORMING SYSTEMS INC., CA

(72) **Inventeurs/Inventors:**
RICHARDSON, GEORGE DAVID, CA;
KRIVULIN, SEMION, CA

(74) **Agent:** OYEN WIGGS GREEN & MUTALA LLP

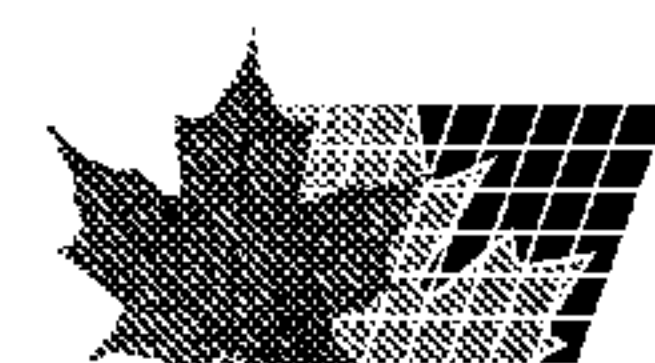
(54) **Titre : PROCÉDES ET APPAREIL POUR FACILITER LE MOUVEMENT COULISSANT RELATIF ENTRE DES STRUCTURES**

(54) **Title: METHODS AND APPARATUS FOR FACILITATING RELATIVE SLIDEABLE MOVEMENT BETWEEN STRUCTURES**



(57) **Abrégé/Abstract:**

Methods and apparatus are provided for permitting relative slideable movement between structures. One or more slip membranes are positioned between first and second structures. The slip membranes reduce the coefficient of friction and/or break surface tension between the structures. The slip membranes may be chemically incompatible with one another and repel one another. The slip membranes may have a textured or non-smooth surface. Features provided on the slip membrane may facilitate drainage of fluid away from the structures or help with receiving or retaining lubricant material.



Abstract of the Disclosure

Methods and apparatus are provided for permitting relative slideable movement between structures. One or more slip membranes are positioned between first and second structures. The slip membranes reduce the coefficient of friction and/or break surface
5 tension between the structures. The slip membranes may be chemically incompatible with one another and repel one another. The slip membranes may have a textured or non-smooth surface. Features provided on the slip membrane may facilitate drainage of fluid away from the structures or help with receiving or retaining lubricant material.

METHODS AND APPARATUS FOR FACILITATING RELATIVE
SLIDEABLE MOVEMENT BETWEEN STRUCTURES

Technical Field

5 [0001] The technology described herein relates to methods and apparatus for facilitating relative slideable movement between structures. Particular embodiments relate to slip membranes.

Background

10 [0002] There are many wide varying reasons to provide bores in the ground. By way of non-limiting example, such bores can be used for fluid conduits (e.g. gas pipelines, aqueducts, sewers and/or the like), accesses to underground regions (e.g. manhole shafts, mine shafts, water wells and/or the like), supports for above-grade structures (e.g. supports for bridges, buildings, towers, road infrastructure and/or the like) and/or other applications. In some cases, the bore may be reinforced with concrete or other similar curable construction material, or the interior surface of the bore may be otherwise
15 covered with concrete or other similar curable material.

[0003] Sometimes one or more structures may be constructed or inserted within the bore. For example, a working platform, elevator shaft, fluid conduit, reinforcement structure and/or other structure may be constructed in the bore. The ground may at some point shift or move due to settling, seismic activity, flooding, thermal expansion or contraction, or
20 other causes. Such movement may cause the bore walls to bend, shift and/or break. This can result in structural damage to the one or more structures within the bore.

[0004] Buildings and non-building structures (such as, for example, towers, piers, bridges, tunnels, parking structures, and other structures) can also be subject to movement. Wind, seismic activity or other ground movement, thermal expansion or
25 contraction and/or other factors may cause the structure or parts of the structure to bend, shift and/or break and may result in structural damage.

[0005] There is a general desire for methods and apparatus that address the
aforementioned problems. In particular, there is a desire for methods and apparatus to
reduce structural damage in the event that structures are subject to external forces. In
some applications, there may be a desire to provide for relative slideable movement
5 between structures to help avoid or reduce structural damage.

Summary

[0006] The technology described herein has a number of aspects. These include, without
limitation: methods for enabling relative slideable movement between structures;
methods and apparatus for reducing coefficient of friction and/or breaking surface tension
10 between contacting surfaces; and slip membranes and materials.

[0007] One aspect provides for the placement of one or more slip membranes between
opposing and adjacent walls of adjacent structures to facilitate relative slideable
movement between the structures. In some embodiments, one or more of the slip
membranes may be bonded to the wall of a structure.

15 [0008] In embodiments where two slip membranes are placed between adjacent
structures, one of the slip membranes may be made of a material which is chemically
incompatible with the other one of the slip membranes, causing the slip membranes to
repel each other. This may help to reduce the coefficient of friction between the slip
membranes.

20 [0009] Each slip membrane may have a textured or non-smooth surface on one or both
sides. In some cases, the textured surface may have properties that help to bond the slip
membrane to the contacting surface (e.g. such as to a concrete wall of a structure). In
other cases, the textured surface may have properties that help to reduce the coefficient of
friction between the slip membrane and a contacting surface (e.g. which may be another
25 slip membrane or the lining or wall of a structure). Features on the slip membrane's
surface, such as ridges, channels, depressions, furrows and the like, may assist in
drainage of fluids away from the structures, or may assist in retaining lubricant material.

[0010] In addition to the exemplary aspects and embodiments described above, further aspects and embodiments will become apparent by reference to the drawings and by study of the following detailed descriptions.

Brief Description of Drawings

5 [0011] In drawings which illustrate non-limiting embodiments:

Figure 1A and Figure 1B (together, Figure 1) are respectively isometric and top plan sectional views of an exemplary bore in which may be installed a structure along with one or more slip membranes according to particular embodiments;

10 Figure 2 is a partial top plan sectional view of exemplary first and second structures between which are installed two slip membranes according to one embodiment;

Figure 3 is a partial top plan sectional view of exemplary first and second structures between which are installed two slip membranes according to another embodiment;

15 Figure 4 is a partial top plan sectional view of exemplary first and second structures between which are installed three slip membranes according to another embodiment;

20 Figure 5 is a partial top plan sectional view of exemplary first and second structures between which are installed two slip membranes according to another embodiment;

Figure 6 is a partial top plan sectional view of exemplary first and second structures between which are installed three slip membranes according to another embodiment;

25 Figure 7 is a partial top plan sectional view of exemplary first and second structures between which is installed a slip membrane according to another embodiment;

Figures 8A, 8B, 8C, 8D, 8E, 8F and 8G (together, Figure 8) are partial top plan sectional views of slip membranes according to particular embodiments shown installed between exemplary structures;

30 Figure 9 is a partial top plan sectional view of exemplary first and second structures between which is installed a slip membrane according to another embodiment;

Figure 10 is a partial top plan sectional view of exemplary first and second structures between which are installed two slip membranes according to another embodiment; and

5 Figure 11 is a partial top plan sectional view of exemplary first and second structures between which is installed a slip membrane according to another embodiment.

Description

[0012] Throughout the following description, details are set forth in order to provide a more thorough understanding to persons skilled in the art. However, well known elements may not have been shown or described in detail to avoid unnecessarily
10 obscuring the disclosure. Accordingly, the description and drawings are to be regarded in an illustrative, rather than a restrictive, sense.

[0013] Figures 1A and 1B are respectively isometric and top plan sectional views of an exemplary bore **10** for which the need may arise for embodiments of the technology described herein. Exemplary bore **10** happens to be fabricated in the earth **16** and
15 happens to be vertically oriented, although this is not necessary. Other bores may be fabricated in other materials and/or have other orientations. Bore **10** comprises an interior bore wall **12** which defines an elongated bore hole **14**. In the illustrated embodiment, interior bore wall **12** is shaped such that bore hole **14** is generally circular in cross-section. Again, however, this is not necessary and embodiments of the technology
20 described herein could be used in bores having other cross-sections. In addition, as explained below, the need for embodiments of the technology described herein could arise in structures other than bores. Particular embodiments of the technology described herein may therefore be applied in structures other than bores.

[0014] There are many wide varying reasons to provide bores such as bore **10**. By way of
25 non-limiting example, such bores can be used for fluid conduits (e.g. gas pipelines, aqueducts, sewers and/or the like), accesses to underground regions (e.g. manhole shafts, mine shafts, water wells and/or the like), supports for above grade structures (e.g.

supports for bridges, buildings, towers, road infrastructure and/or the like) and/or other applications.

[0015] In one particular application, bore **10** may be formed as follows: a cutting tool may be used to cut a generally annular-shaped cylinder in the ground; the annular
5 cylinder may be filled with a temporary filler material (e.g. bentonite clay or the like) at about the same time as earth is removed from the annular cylinder. Then, concrete may be pumped to the bottom of the annular cylinder, forcing the temporary filler material out the top of the annular cylinder. The concrete pumped into the annular cylinder cures
10 between the earth that forms the inside and outside surfaces of the annular cylinder to provide an annular cylinder of solidified concrete **18** (Figure 1B). The earth inside concrete annular cylinder **18** may then be excavated or otherwise removed using any suitable means. This excavation creates bore hole **14**. Bore hole **14** is defined by an interior bore wall **12** which is the interior surface of concrete annular cylinder **18**. Where
15 annular cylinder **18** originally cut into earth **16** has a generally round cross-section (as is the case in the illustrated bore **10** of Figure 1), bore hole **14** may also have a generally round cross-section. However, because of the non-homogeneous nature of earth **16** in which bore **10** is formed, generally annular cylinder **18** and interior bore wall **12**
20 fabricated in this manner may be uneven, rough and may have significant amounts of earth, rock and/or other material embedded therein or otherwise stuck thereto. In addition to reinforcing bore **10**, in some applications, it might be desirable to provide a bore-hole defining surface that is relatively smooth and/or uncontaminated in comparison to interior bore wall **12**.

[0016] The preceding description represents one particular non-limiting technique for creating a bore **10** defined by an interior bore wall **12** and having a bore hole **14**.
25 Generally speaking, however, bores like bore **10** may be created by any other suitable technique which is known or which may become known in the art, and embodiments of the technology described herein should be understood to have application to any such bores. For the purposes of explanation, the description that follows will refer to bore **10** of Figure 1, without loss of generality.

[0017] It is often desirable to reinforce bores, particularly bores formed in the earth or in other non-homogeneous or non-stable materials. Such reinforcement can prevent or minimize the amount of material from interior bore wall **12** or from the surrounding material (e.g. earth **16**) which collapses into bore hole **14**. Bore reinforcing structures
5 may be fabricated in part from concrete or other curable construction materials. For example, bore **10** is optionally reinforced to provide a lined reinforcement structure that covers at least a portion of an interior wall **12** of bore **10**.

[0018] The interior bore wall **12**—along with its reinforcement structure if bore **10** is reinforced—can be considered a first structure. In some cases, a second structure is
10 constructed or installed within the bore. For example, a second structure consisting of a working platform, elevator shaft, fluid conduit, reinforcement structure and/or other structure may be constructed in the bore. The second structure (or portions of the second structure) may be constructed such that it is not coupled to or attached to the first structure. Parts of the second structure (e.g. an outer wall of the second structure) may be
15 located proximate to or in contact with surfaces of the first structure.

[0019] The ground in which the first structure is located may at some point shift or move due to settling, seismic activity, flooding, thermal expansion or contraction, or other causes. In some cases, the first structure is designed and constructed to accommodate some degree of movement. For example, in some cases, the first structure may be
20 designed to shift, flex, bend, or otherwise move at various locations upon the application of external forces. The movement of the first structure may help to avoid catastrophic failure of the entire structure or reduce the structural damage.

[0020] Where a second structure is located within or adjacent a first structure, the movement of the first structure may cause the first structure to exert forces against the
25 second structure. If the friction between contacting surfaces of the first and second structures renders the second structure incapable of moving independently of the first structure, the second structure can become damaged.

[0021] Embodiments of the technology described herein address the aforementioned problem through the placement of one or more slip membranes between structures to enable relative slideable movement between the structures. The slip membranes help to reduce the friction and/or cohesive forces that prevent structures from moving relative to one another.

[0022] Figure 2 is a partial top plan sectional view of first and second structures 20, 22 between which are installed first and second slip membranes 24, 26 according to one embodiment. The coefficient of friction between slip membranes 24, 26 is sufficiently low so that when forces are applied to cause one or more of structures 20, 22 to move, slip membranes 24, 26 are capable of sliding relative to one another, permitting relative slideable movement of structures 20, 22.

[0023] Each of structures 20, 22 may be a structural wall, pillar, floor, ceiling, roof or other structure. For example, first structure 20 may be the interior bore wall 12 of Figure 1's bore 10, forming an "original" or existing structure. Second structure 22 may be a "new" structure constructed or installed within bore 10. Structures 20, 22 may be fabricated in part from concrete or other curable construction materials. However, this is not necessary. As described below for other embodiments (for example, the embodiment in Figures 9 and 10), structures 20, 22 may be fabricated from other materials.

[0024] In the illustrated embodiment of Figure 2, first structure 20 includes an outer surface leveling layer 20A. To create surface leveling layer 20A, grout, concrete, shotcrete, plaster or other suitable curable construction material may be applied to fill in the surface irregularities (gaps, voids, crevices and the like) of first structure 20, forming a rigid, smooth surface leveling layer 20A once dried. Surface leveling layer 20A is optional. In other embodiments, first structure 20 does not include a surface leveling layer 20A (as illustrated in Figure 3, for example).

[0025] As seen in Figure 2, first structure 20 has an outer surface 20B on outer surface leveling layer 20A. Second structure 22 has an outer surface 22B opposing first structure 20's outer surface 20B. The coefficient of friction between opposing outer surfaces 20B,

22B can be quite high. This is typically the case if surface leveling layer **20A** is formed of grout or concrete and second structure **22** is formed of concrete. A high coefficient of friction may prevent structures **20, 22** from moving or sliding relative to one another when either of these structures is made to move. This may result in structural damage to one or both of the structures.

[0026] To facilitate relative slideable movement between structures **20, 22**, slip membranes **24, 26** may be placed between structures **20, 22**. In some embodiments, one or both of slip membranes **24, 26** may comprise a plurality of sheets, panels or sections that are positioned in a single layer to line a surface of a structure. For example, a plurality of panels may be positioned to form a slip membrane **24** lining a surface **20B** of structure **20**. In other embodiments, one or both of slip membranes **24, 26** may be a continuous film or sheet. In some applications, it may not be necessary to cover the entire surface of a structure with a slip membrane. For example, it may be sufficient to cover one or more portions of surface **22B** of structure **22** with slip membrane **26**.

[0027] Where surfaces **20B, 22B** are curved (such as in the illustrated example of Figure 2) or irregular in shape, it may be desirable to provide slip membranes **24, 26** that are sufficiently flexible to contour to the surfaces. In other embodiments (such as in the illustrated examples of Figures 6, 9, 10 and 11), the surfaces of the structures may be substantially flat or level. In such cases, the slip membranes may be rigid, semi-rigid or flexible.

[0028] As seen in Figure 2, first slip membrane **24** is positioned between structures **20, 22** and adjacent to structure **20**'s outer surface **20B**. In the illustrated embodiment, first slip membrane **24** also functions as an additional surface leveling layer applied to first structure **20**'s outer surface **20B**. Slip membrane **24** may be made of a compressible material such as foam, fabric or other crushable material. In such embodiments, when slip membrane **24** is bonded, adhered, or otherwise attached to first structure **20**, the material at slip membrane **24**'s side **24B** can fill in any surface irregularities (gaps, voids, crevices and the like) present at first structure **20**'s outer surface **20B**. This creates a smoother surface and may reduce the coefficient of friction between slip membranes **24, 26**.

[0029] Second slip membrane **26** is placed between first slip membrane **24** and second structure **22**'s outer surface **22B**. Slip membrane **26** may be bonded, adhered or otherwise attached to second structure **22**'s outer surface **22B**. In some applications, the material used for slip membrane **26** may have certain properties which make it chemically
 5 incompatible with the material of slip membrane **24**. This can result in slip membranes **24, 26** repelling one another, which can help to reduce the coefficient of friction between slip membranes **24, 26**. Slip membranes **24, 26** may be made of one or more materials that contribute to sliding (e.g. they are materials that are inherently slippery and have low coefficient of friction) and tend to cause the sliding surfaces to repel one another.

10 [0030] First slip membrane **24** has a first side or surface **24A** which is adjacent to (and in contact with) second slip membrane **26**, and a second side or surface **24B** which is adjacent to structure **20**'s outer surface **20B**. Second slip membrane **26** has a first side or surface **26A** which is adjacent to (and in contact with) first slip membrane **24**, and a second side or surface **26B** which is adjacent to structure **22**'s outer surface **22B**. Slip
 15 membranes **24, 26** can move relative to one another if the frictional forces between contacting sides **24A, 26A** are overcome. Slip membranes **24, 26** may move in a number of different directions. The directions of movement may be constrained by the geometry of the structures. For example, in the case of vertically-oriented annular cylindrical structures **20, 22** as may be installed for Figure 1's bore **10**, one of slip membranes **24, 26**
 20 may slide relative to the other in a vertical direction (i.e. up or down) and/or may rotate about an axis of bore **10**. Slip membranes **24, 26** may move generally in a plane defined by slip membranes **24, 26** at their contacting surfaces.

[0031] It is desirable to have a low coefficient of friction between slip membranes **24, 26**, to facilitate relative movement between structures **20, 22**. In some applications, for
 25 example, it may be desirable that the coefficient of static friction is below 0.6. In some other applications, it may be desirable that the coefficient of static friction is below 0.25. In particular applications, it may be desirable that the coefficient of static friction approaches 0.1 or is 0.1 or below. In some applications, different thresholds may apply for the coefficient of kinetic friction. For example, the coefficient of kinetic friction may

not need to be as low as the coefficient of static friction. Suitable materials may be selected for slip membranes **24**, **26** so that the desired values of coefficients of friction are achieved between the contacting surfaces **24A**, **26A** of slip membranes **24**, **26**.

[0032] By way of non-limiting example, materials that may be used for slip membranes **24**, **26** include polyethylene, polypropylene or other plastics, silicone, ceramics, foam, metal, and woven or non-woven textiles. First slip membrane **24** may be made of one or more different materials from second slip membrane **26**. As discussed above, slip membranes **24**, **26** may be made of chemically incompatible materials.

[0033] As discussed above, in the Figure 2 embodiment, slip membranes **24**, **26** may be bonded, adhered or otherwise attached to structures **20**, **22** respectively, providing a slip interface or sliding interface between slip membranes **24**, **26**, but not between slip membrane **24** and first structure **20**, or between slip membrane **26** and second structure **22**. The bonding of slip membranes **24**, **26** to adjacent structures is not necessary for all embodiments. In other embodiments, an additional sliding interface may be provided between a slip membrane and the adjacent structure by not bonding the slip membrane to the structure. For example, in the Figure 2 embodiment, if slip membrane **24** is not bonded to structure **20**, then slip membrane **24** would be free to slide relative to first structure **20** if the friction between first structure **20**'s surface **20B** and slip membrane **24**'s surface **24B** is overcome. Similarly, in the Figure 2 embodiment, if slip membrane **26** is not bonded to structure **22**, then slip membrane **26** would be free to slide relative to second structure **22** if the friction between second structure **22**'s surface **22B** and slip membrane **26**'s surface **26B** is overcome. Therefore, in the Figure 2 embodiment, there can be up to three sliding interfaces if the slip membranes are not bonded to their adjacent structures: one between the slip membranes' contacting surfaces **24A**, **26A**, one other between first structure **20**'s surface **20B** and slip membrane **24**'s surface **24B**, and one other between second structure **22**'s surface **22B** and slip membrane **26**'s surface **26B**. In certain embodiments, the coefficient of friction between slip membrane **24** and first structure **20** or between slip membrane **26** and second structure **22** may not need to be as low as the coefficient of friction between slip membranes **24**, **26**, since the contacting

surfaces **24A**, **26A** between slip membranes **24**, **26** may act as the primary sliding interface.

[0034] One or both of slip membranes **24**, **26** may be formed of different materials and/or have different properties at each side. For example, side **24B** of first slip membrane **24** may be made of a certain material and have various properties that make it suitable for bonding to first structure **20**'s outer surface **20B**. In other embodiments where first slip membrane **24** is not bonded to first structure **20** given that a sliding interface is intended between first slip membrane **24** and first structure **20**, side **24B** of first slip membrane **24** may be made of a material and have various properties that make it suitable for sliding relative to first structure **20**'s outer surface **20B**. The other side **24A** of slip membrane **24** (i.e. the side that contacts second slip membrane **26**) may be made of a different material and have various other properties that, when factored together with the particular material and various properties of side **26A** of slip membrane **26**, serve to keep the coefficient of friction against side **26A** of slip membrane **26** below a threshold value. Side **26B** of second slip membrane **26** may be made of a material and have various properties that make it suitable for bonding to second structure **22**'s outer surface **22B**. In other embodiments where second slip membrane **26** is not bonded to second structure **22** given that a sliding interface is intended between second slip membrane **26** and second structure **22**, side **26B** of second slip membrane **26** may be made of a material and have various properties that make it suitable for sliding relative to second structure **22**'s outer surface **22B**. The other side **26A** of second slip membrane (i.e. the side that contacts first slip membrane **24**) may be made of a different material and have various properties that, when factored together with the particular material and various properties of side **24A** of slip membrane **24**, serve to keep the coefficient of friction against side **24A** of slip membrane **24** below a threshold value.

[0035] The materials or composition of each slip membrane (or each side of a slip membrane) may be selected or designed to take into account the characteristics or properties of any surfaces or materials which contact the slip membrane. For example, if it is known that one side of a slip membrane will contact and be required to bond with a

structural wall formed of concrete, but the other side of the slip membrane will contact and be required to slide relatively freely against a textile material, then a material which may be suitable for use as the slip membrane is one that bonds to concrete, but also repels and has a low coefficient of friction against the textile material. In other applications, it may be desirable to use different materials for each side of a slip membrane so that the desired response is achieved at each side (e.g. bonding or sliding). Exemplary slip membranes are shown and described below with reference to Figure 8.

[0036] In some embodiments, to enhance the sliding properties of a slip membrane, a paint or film may be applied to one or both sides of a slip membrane. For example, in the Figure 2 embodiment, a paint or film may be applied to slip membrane **24**'s surface **24A** and/or to slip membrane **26**'s surface **26A** to decrease the coefficient of friction between slip membranes **24**, **26**. Suitable paints that may be used for this purpose may include, for example, PVC paint. Suitable films that may be used for this purpose may include, for example, polyurethane films or PVC films. Such films may be laminated, coextruded with, or otherwise applied to the slip membrane prior to installation of the slip membrane.

[0037] Figure 3 is a partial top plan sectional view of first and second structures **20**, **22** between which are installed first and second slip membranes **24**, **26'** according to another embodiment. The Figure 3 embodiment is similar in some respects to the Figure 2 embodiment, and similar reference numerals are used in the description herein and the drawings to refer to the similar components (including, for example, first structure **20**, second structure **22**, first structure **20**'s outer surface **20B**, and second structure **22**'s outer surface **22B**). The Figure 2 description applies also to the similar components in the Figure 3 embodiment. The Figure 3 embodiment does not include a surface leveling layer **20A** as shown in Figure 2. The Figure 3 embodiment also differs from the Figure 2 embodiment in that Figure 3's second slip membrane **26'** includes a plurality of bumps **30** on the surface of slip membrane **26'** which is adjacent to first slip membrane **24** (i.e. on side **26A** of slip membrane **26'**). Bumps **30** extend toward and may contact side **24A** of slip membrane **24** as spaced apart locations on side **24A**. By way of non-limiting example, bumps **30** may consist of ridges, round or hemispherical protrusions, beads, or

protrusions in other shapes. Bumps **30** may be formed in a regular (e.g. directional) or irregular (e.g. random) pattern on side **26A** of slip membrane **26**.

[0038] Bumps **30** may serve one or more purposes. In some applications, bumps **30** may be useful to help reduce the coefficient of friction between slip membranes **24**, **26'**. In
 5 some applications, bumps **30** provide a textured or non-smooth surface on slip membrane **26'** to permit fluid to flow interspatially and help break the surface tension that would otherwise bond membranes **24**, **26'** together in the event that water (or other fluid) is trapped in the spaces between the membranes. In other applications, bumps **30** may be
 10 useful to help with the drainage of fluids away from slip membranes **24**, **26'** and structures **20**, **22**. If bumps **30** are sufficiently rigid, then they can provide channels, valleys and the like (between the bumps) in which fluid may be drained away from the structures.

[0039] In other embodiments, it may be desirable to maintain lubricant or other fluids between the membrane and an adjacent surface. For example, in the Figure 3
 15 embodiment, lubricant may be introduced by way of gravity or pressure into the spaces around bumps **30** in order to contribute to a reduction in the coefficient of friction between surface **26A'** of slip membrane **26'** and surface **24A** of slip membrane **24**. Bumps **30** may help to retain the lubricant in the spaces between slip membranes **24**, **26**.

[0040] In certain applications, bumps **30** may be useful for a combination of the purposes
 20 described above—i.e. reducing coefficient of friction, breaking surface tension, and/or facilitating drainage (or alternately, receiving and retaining lubricant to facilitate movement between the structures).

[0041] As with the Figure 2 embodiment, in the Figure 3 embodiment one or both of slip membranes **24**, **26'** may be bonded to an adjacent structure. However, there can be up to
 25 three sliding interfaces in certain embodiments if the slip membranes are not bonded to their adjacent structures: one between the slip membranes' contacting surfaces **24A**, **26A'**, one other between surface **20B** of first structure **20** and surface **24B** of first slip

membrane **24**, and one other between surface **22B** of second structure **22** and surface **26B'** of second slip membrane **26'**.

[0042] Figure 4 is a partial top plan sectional view of first and second structures **20**, **22** between which are installed first, second and third slip membranes **24**, **26**, **28** according to another embodiment. The Figure 4 embodiment is similar in some respects to the Figure 2 and 3 embodiments, and similar reference numerals are used in the description herein and the drawings to refer to the similar components (including, for example, first structure **20**, second structure **22**, surface leveling layer **20A**, first structure **20**'s outer surface **20B**, and second structure **22**'s outer surface **22B**). The Figure 2 description applies also to the similar components in the Figure 4 embodiment. The Figure 4 embodiment differs from the Figure 2 and 3 embodiments in that the Figure 4 embodiment includes a third slip membrane **28** placed between first and second structures **20**, **22**.

[0043] As seen in Figure 4, third slip membrane **28** may be positioned between first and second slip membranes **24**, **26**. Slip membrane **28** is preferably not bonded to any of the adjacent surfaces, so that slip membrane **28** can slide relative to the adjacent or contacting surface on either side. The inclusion of third slip membrane **28** provides sliding surfaces on either side of slip membrane **28**, in order to facilitate relative movement of structures **20**, **22**.

[0044] Slip membrane **28** has a first side **28A** in contact with side **24A** of first slip membrane **24**. Slip membranes **24**, **28** can move relative to one another if the frictional forces between sides **24A**, **28A** are overcome. Slip membrane **28** has a second side **28B** in contact with side **26A** of second slip membrane **26**. Slip membranes **26**, **28** can move relative to one another if the frictional forces between sides **26A**, **28B** are overcome. Slip membrane **28** may be made of a material that is chemically incompatible with the materials of slip membranes **24**, **26**, so as to repel these slip membranes and reduce the coefficient of friction between sides **24A**, **28A** and between sides **26A**, **28B**.

[0045] By way of non-limiting example, materials that may be used for slip membranes **24**, **26**, and **28** of Figure 4 include polyethylene, polypropylene or other plastics, silicone, ceramics, foam, metal, and woven or non-woven textiles. Suitable materials may be selected for slip membranes **24**, **26** and **28** so that the desired values of coefficients of friction are achieved between slip membranes **24**, **28** and between slip membranes **26**, **28**.

[0046] As with slip membranes **24**, **26**, for some applications slip membrane **28** may be formed of different materials and/or have different properties at each of sides **28A**, **28B**. The materials or composition of each side of slip membrane **28** may be selected or designed to take into account the characteristics or properties of the surfaces or materials which contact the slip membrane. For example, side **28A** of slip membrane **28** (i.e. the side that contacts first slip membrane **24**) may be made of a certain material and have various properties that serve to keep the coefficient of friction against side **24A** of slip membrane **24** below a threshold value. The other side **28B** of slip membrane **28** (i.e. the side that contacts second slip membrane **26**) may be made of a different material and have various properties that serve to keep the coefficient of friction against side **26A** of slip membrane **26** below a threshold value.

[0047] One advantage of including slip membrane **28** is that it provides dual sliding interfaces—one on each of sides **28A**, **28B** of membrane **28**, as described above. Having more than one sliding interface may provide additional opportunities for the structures to slip against one another, thereby reducing the overall coefficient of friction between the structures.

[0048] In some applications, dual sliding interface may be provided as shown in Figure 4, with each sliding interface customized for a different application. For example, some materials may have low friction between them when dry, but will not slide as easily when they are wet. Other materials may have low friction between them when wet, but will not slide as easily when they are dry. So that structures **20**, **22** are able to overcome friction whether or not there is fluid between the structures, one sliding interface may be made more suitable for dry sliding while another sliding interface may be made more suitable for wet sliding by choosing appropriate materials for each of the contacting sides of the

slip membranes in each case. In this manner, even if one sliding interface becomes “stuck” because the materials do not slide easily in the particular circumstances, the other sliding interface may still enable relative movement between the structures.

[0049] In other embodiments, more than two sliding interfaces may be provided between structures with the installation of additional sliding membranes. In particular, a plurality of slip membranes may be positioned between structures **20**, **22** so that a total of 3, 4 or more sliding interfaces may be provided (i.e. one between each pair of adjacent slip membranes). As discussed above with reference to Figures 2 and 3, additional sliding interfaces may be provided between an outermost slip membrane (such as slip membrane **26** or slip membrane **24** in Figure 4) and the adjacent structure if the slip membrane is not bonded to the structure.

[0050] Figure 5 is a partial top plan sectional view of first and second structures **20**, **22** between which are installed first and second slip membranes **24**, **26"** according to another embodiment. The Figure 5 embodiment is similar in some respects to the Figure 3 embodiment, and similar reference numerals are used in the description herein and the drawings to refer to the similar components (including, for example, first structure **20**, second structure **22**, first structure **20**'s outer surface **20B**, and second structure **22**'s outer surface **22B**). The Figure 3 description applies also to the similar components in the Figure 5 embodiment. However, the Figure 5 embodiment differs from the Figure 3 embodiment in that Figure 5's second slip membrane **26"** includes a plurality of hairs or fibres **32** on the surface of slip membrane **26"** which is adjacent to first slip membrane **24** (i.e. on side **26A** of slip membrane **26"**). Hairs **32** extend toward and may contact side **24A** of slip membrane **24**. Slip membrane **26"** may be made of a textile material. An optional lubricant material **33** may be applied between slip membranes **24**, **26"** to reduce the coefficient of friction between these layers.

[0051] As with the bumps **30** shown in the Figure 3 embodiment, hairs **32** of the Figure 5 embodiment may serve one or more purposes. In some applications, hairs **32** may be useful to help reduce the coefficient of friction between slip membranes **24**, **26"**. Hairs **32** may also be useful to help break the surface tension that would otherwise bond

membranes **24, 26''** together in the event that water or other liquid is trapped between the membranes. In some applications, hairs **32** may be sufficiently rigid to provide spaces and channels useful to help with the drainage of fluids away from slip membranes **24, 26''** and structures **20, 22**. In other applications where lubricant material **33** is introduced
5 between slip membranes **24, 26''**, hairs **32** may be useful to help retain lubricant material **33** or other fluids to contribute to a reduction in the coefficient of friction.

[0052] In particular embodiments, hairs **32** may be oriented primarily in a single direction (at an angle to slip membrane **26''**) to permit sliding of slip membrane **26''** in only one direction. In other embodiments, hairs **32** may be oriented in different directions
10 or in a direction perpendicular to slip membrane **26''** to enable sliding of slip membrane **26''** in more than one direction.

[0053] Figure 6 is a partial top plan sectional view of first and second structures **20, 22** between which are installed first, second and third slip membranes **24, 26, 28** according to another embodiment. The Figure 6 embodiment is similar in some respects to the
15 Figure 4 embodiment, and similar reference numerals are used in the description herein and the drawings to refer to the similar components (including, for example, first structure **20**, second structure **22**, surface leveling layer **20A**, first structure **20**'s outer surface **20B**, and second structure **22**'s outer surface **22B**). The Figure 4 description applies also to the similar components in the Figure 6 embodiment. The Figure 6
20 embodiment differs from the Figure 4 embodiment in that the walls of the Figure 6 structures **20, 22** are not curved. In the Figure 6 embodiment, structures **20, 22** are square or rectangular structures (a corner of each structure is shown in Figure 6). Figure 6 illustrates that slip membranes **24, 26, 28** can also be used with non-cylindrical or non-curved structures to facilitate relative movement between such structures. Slip
25 membranes **24, 26, 28** of Figure 6 may have similar characteristics and be installed and function in a similar manner to the slip membranes described with respect to Figure 4. In other embodiments, slip membranes **24, 26, 28** may be installed between other non-cylindrical or non-curved structures such as sections of flat opposing surfaces or walls.

[0054] Figure 7 is a partial top plan sectional view of first and second structures **20**, **22** between which is installed a slip membrane **26** according to one embodiment. The Figure 7 embodiment is similar in some respects to the Figure 2 embodiment, and similar reference numerals are used in the description herein and the drawings to refer to the similar components (including, for example, first structure **20**, second structure **22**, first structure **20**'s outer surface **20B**, and second structure **22**'s outer surface **22B**). The Figure 2 description applies also to the similar components in the Figure 7 embodiment. The Figure 7 embodiment differs from the Figure 2 embodiment in that Figure 7 shows a stay-in-place form **34** that is used to fabricate structure **20**. For example, form **34** may be assembled next to an interior bore wall **12** (or other wall), and then concrete **21** or other curable material is poured into form **34** to fill the space between form **34** and interior bore wall **12**. Form **34** may be assembled by connecting together panels or sections that are made of plastic, metal or other rigid material. By way of example, form **34** may comprise a form for lining a concrete-reinforced bore (and may optionally be lined) as described in the applicant's Canadian patent application No. 2,714,763 filed on September 20, 2010, and entitled "SYSTEMS AND METHODS FOR PROVIDING A CONCRETE-REINFORCED BORE". However, this is not necessary. In other embodiments, other suitable forms, including forms for applications other than a concrete-reinforced bore, may be installed as form **34** in Figure 7. For example, a form may be fabricated to line or cover a wide variety of existing structures including a bore, tank, wall, column, or structures of different shapes that may be curved or round or be comprised of two or more relatively flat surfaces.

[0055] In the Figure 7 embodiment, slip membrane **26** is positioned between form **34** and structure **22**. Figure 7's slip membrane **26** may have similar characteristics to Figure 2's slip membrane **26**. Slip membrane **26** functions to provide relative slideable movement between structure **20** (including form **34**) and structure **22**. In some embodiments, slip membrane **26** is bonded to structure **22** or to form **34**, and provides a sliding interface on the side of slip membrane **26** that is not bonded. In other embodiments, slip membrane **26** is not bonded to either structure **22** or form **34**, and provides for a sliding interface on either side of the slip membrane. Slip membrane **26** may be made of a certain material

and have various properties that serve to keep the coefficient of friction between slip membrane **26** and adjacent sliding surfaces (such as on form **34**) below a threshold value.

[0056] To reduce the coefficient of friction and facilitate sliding between structures **20**, **22** in the Figure 7 embodiment, in some cases a paint or film may be applied to one or both sides of slip membrane **26**, and/or to the side of form **34** that is adjacent to slip membrane **26**. In the Figure 7 embodiment, a paint coating **27** is applied to form **34**. Suitable paints that may be used for this purpose may include, for example, PVC paint. Suitable films that may be used for this purpose may include, for example, polyurethane films or PVC films. Such films may be laminated, coextruded with, or otherwise applied to slip membrane **26** or the panels or sections of form **34**.

[0057] Figure 8 shows partial top plan sectional views of slip membranes according to particular embodiments installed between structures **20**, **22**. Figure 8A shows a slip membrane **40** made of foam and having a rippled or corrugated surface **40A** on one side. Figure 8B shows a slip membrane **42** having fibers or hairs extending from side **42A**. Figure 8C shows a slip membrane **44** made of fabric.

[0058] Figures 8D and 8E show different embodiments of corrugated slip membranes **52**, **54**, respectively, between first and second structures **20**, **22**. Slip membranes **52**, **54** have a corrugated or rippled surface such that most of the surface area of first structure **20** is not in contact with slip membranes **52**, **54**; as seen in Figures 8D and 8E only the peaks of the corrugated surface are in contact with first structure **20**.

[0059] Figure 8F shows a smooth slip membrane **46** made of a low friction material (e.g. polyethylene, polypropylene). Figure 8G shows textured slip membranes **47**, **48**. Slip membranes **47**, **48** have bumps, protrusions or ridges. Slip membrane **47** has a random textured pattern **49** on its surface. Slip membrane **48** has a directional textured pattern **50** on its surface. One or more of the slip membranes illustrated in Figure 8 may be used in the embodiments described herein to reduce coefficient of friction and facilitate relative slideable movement between structures.

[0060] Figure 9 is a partial top plan sectional view of first and second structures **20'**, **22'** between which is installed a slip membrane **28'** according to another embodiment. Slip membrane **28'** functions to reduce the coefficient of friction and enable relative slideable movement between structures **20'**, **22'**. Unlike the examples described above, structures **20'**, **22'** of Figure 9 are structural walls that may be made of brick, concrete, stone, concrete masonry unit (CMU), steel, wood, soil, gravel or a combination of any of these materials. As shown in Figure 9, optional surface leveling layers **20A'**, **22A'** (formed of grout, concrete, shotcrete, plaster or other suitable curable construction material) may be applied at opposing and adjacent sides of structures **20'**, **22'** respectively. A slip membrane **28'** is placed between surface leveling layers **20A'**, **22A'**. The slip membrane **28'** of Figure 9 may have similar characteristics to the slip membrane **28** of Figure 4, and provides dual sliding interfaces, i.e. one on either side of the membrane. The materials and composition of each side of the Figure 9 slip membrane **28'** may be selected or designed to take into account the characteristics or properties of the surfaces or materials which contact the slip membrane.

[0061] In other embodiments, slip membrane **28'** is bonded to one of structures **20'**, **22'**, resulting in only one sliding interface (i.e. on the side that is not bonded to a structure).

[0062] Figure 10 is a partial top plan sectional view of first and second structures **20'**, **22'** between which are installed two slip membranes **28**, **29** according to another embodiment. The example of Figure 10 is similar in many respects to the example of Figure 9, except that Figure 10 includes two slip membranes as opposed to the one shown in Figure 9. Slip membranes **28**, **29** may be made of chemically incompatible materials so that they repel one another and have a low coefficient of friction. One or both of slip membranes **28**, **29** is optionally bonded to surface leveling layers **20A'**, **22A'**, respectively.

[0063] Figure 11 is a partial top plan sectional view of first and second structures **20''**, **22''** between which is installed a single slip membrane **28''** according to another embodiment. Structures **20''**, **22''** may be structural walls that are made of brick, concrete, stone, concrete masonry unit (CMU), steel, wood, soil, gravel or a combination

of any of these materials. Slip membrane **28''** is made from one or more materials having a low coefficient of friction against structures **20''**, **22''**. Slip membrane **28''** may be formed of different materials and/or have different properties at each side. For example, side **28A''** of slip membrane **28''** may be made of a certain material and have various properties that keep the coefficient of friction against structure **20''** below a threshold value. Likewise, side **28B''** of slip membrane **28''** may be made of a certain material and have various properties that keep the coefficient of friction against structure **22''** below a threshold value. In some embodiments, one side of slip membrane **28''** is optionally bonded to one of structures **20''**, **22''**, providing a sliding surface only on the other side of slip membrane **28''** (i.e. on the side that is not bonded to a structure).

[0064] As will be appreciated by a person of skill in the art, to facilitate relative slideable movement between structures, any of the slip membranes described herein may have one or more of the characteristics or properties of a slip membrane described in another embodiment. By way of non-limiting example, slip membrane **28''** of Figure 11 may have characteristics of any one or more of slip membranes **24**, **26** of Figure 2, slip membrane **26'** of Figure 3, slip membrane **28** of Figure 4, or slip membrane **26''** of Figure 5.

[0065] While the drawings show one or more slip membranes on one side of a first structure **20** and an adjacent side of a second structure **22**, in some applications it may be desirable to position one or more slip membranes on both sides of a structure. For example, in some applications, where an existing structure is adjacent to or in contact with another structure on each opposing side of the existing structure, one or more slip membranes may be installed against each side of the existing structure in order to facilitate relative slideable movement between the existing structure and each of the adjacent structures. In some other applications, it may be desirable to install slip membranes on additional sides of a structure (e.g. around the four outer and/or inner walls of a rectangular structure). One or more slip membranes according to the embodiments described herein may be installed wherever it is desirable to reduce coefficient of friction (and/or break surface tension in the case of liquid being trapped

between the surfaces) and enable relative slideable movement between adjacent structures, surfaces or walls.

[0066] Where a component (e.g. structure, wall, lining, membrane, sheet, panel, protrusion, ridge, channel, form, etc.) is referred to above, unless otherwise indicated, reference to that component (including a reference to a “means”) should be interpreted as including as equivalents of that component any component which performs the function of the described component (i.e., that is functionally equivalent), including components which are not structurally equivalent to the disclosed structure which perform the function in the illustrated exemplary embodiments.

[0067] The slip membranes in each embodiment are referred to herein as a “first” slip membrane, “second” slip membrane, “third” slip membrane, etc. Similarly, the structures are referred to herein as a “first” structure and “second” structure. It is to be understood that the labels of “first”, “second”, “third”, etc. are chosen for convenience (e.g. chosen based on the order in which the components are introduced in the specification or in the claims) and do not necessarily correspond to the order in which any particular slip membrane, structure or other component may be installed or positioned. In addition, the references to a “first”, “second” or “third” slip membrane may be specific to each embodiment. For example, a “first” slip membrane in one embodiment may be equivalent to a slip membrane that is referred to as a “second” or “third” slip membrane in another embodiment, or in one of the claims.

[0068] As will be apparent to those skilled in the art in the light of the foregoing disclosure, many alterations and modifications are possible. For example:

- The illustrated embodiments of Figures 3, 5 and 8 show a textured surface (bumps, hairs or other texture) on one side of a slip membrane. In other embodiments, a textured surface may be provided on both sides of a slip membrane. The textured surface on one side of a slip membrane may be the same or different from the textured surface on the opposite side.
- In some of the embodiments described above, one or more of the slip membranes are bonded to adjacent structures. In particular embodiments, a slip membrane

may be semi-bonded to an adjacent structure such that gaps or voids are left between the slip membrane and the structure's surface. This can provide the advantage of allowing excess moisture to drain out between the slip membrane and the adjacent structure.

- 5 • While the slip membranes are generally shown to be installed between structures in the illustrated embodiments, in other embodiments slip membranes may be installed between components such as floors, walls, ceilings, columns and the like. One or more slip membranes according to the embodiments described herein may be installed wherever it is desirable to enable relative slideable movement
- 10 between adjacent surfaces.
- The thickness of the slip membranes may vary between embodiments. The material and thickness for each slip membrane can be chosen to provide the desired rigidity or flexibility, coefficient of friction, and other characteristics suitable for the particular application.
- 15 [0069] While a number of exemplary aspects and embodiments have been discussed above, those of skill in the art will recognize certain modifications, permutations, additions and sub-combinations thereof. It is therefore intended that the scope of the following appended claims and claims hereafter introduced should not be limited by the preferred embodiments set forth in the examples, but should be given the broadest
- 20 interpretation consistent with the description as a whole.

WHAT IS CLAIMED IS:

1. A method for permitting relative slideable movement between first and second structures, the method comprising:

installing between the first and second structures a first slip membrane;

5 wherein the first slip membrane is formed of a first material, selected such that a resulting coefficient of friction between the first and second structures is less than a first threshold value.

2. A method according to claim 1, the first membrane comprising first and second
10 opposed sides, the first side more proximate to the second structure than is the second side, and the second side more proximate to the first structure than is the first side, and wherein the first side comprises a first plurality of raised elements adapted to reduce frictional forces against the second structure.

15 3. A method according to claim 2, wherein the first plurality of raised elements is adapted to break surface tension in fluid trapped between the first slip membrane and the second structure.

4. A method according to claim 3 wherein the second side comprises a second
20 plurality of raised elements adapted to reduce frictional forces against the first structure.

5. A method according to claim 4, wherein the second plurality of raised elements is adapted to break surface tension in fluid trapped between the first slip membrane and the first structure.

25

6. A method according to any one of claims 1 to 3 comprising bonding the first slip membrane to the first structure.

7. A method according to any one of claims 1 to 5 comprising installing a second
30 slip membrane between the first slip membrane and the first structure.

8. A method according to claim 7 wherein the second slip membrane is adapted to fill in surface irregularities on the first structure.

9. A method according to any one of claims 7 to 8 comprising bonding the second
5 slip membrane to the first structure.

10. A method according to any one of claims 7 to 9 wherein the first and second slip membranes are chemically incompatible.

10 11. A method according to any one of claims 7 to 10 comprising inserting a lubricant between the first and second slip membranes.

12. A method according to any one of claims 7 to 11, wherein the second slip membrane comprises a third plurality of raised elements adapted to reduce frictional
15 forces against the first slip membrane.

13. A method according to claim 12, wherein the third plurality of raised elements is adapted to break surface tension in fluid trapped between the first and second slip membranes.

20

14. A method according to any one of claims 7 to 13 wherein the second slip membrane is formed of one or more of the following materials: textile, foam, polypropylene, polyethylene, silicone, ceramics, metal.

25 15. A method according to any one of claims 1 to 14 wherein the first slip membrane is formed of one or more of the following materials: textile, foam, polypropylene, polyethylene, silicone, ceramics, metal.

16. A method according to any one of claims 1 to 15 wherein the first structure
30 comprises a curable material.

17. A method according to any one of claims 1 to 16 wherein the first structure comprises an interior wall of a concrete-reinforced bore.

18. A method according to any one of claims 2 to 5 wherein the first plurality of
5 elements comprises one or more of: fibers, bumps, hemispherical protrusions and beads.

19. A method according to any one of claims 4 to 5 wherein the second plurality of elements comprises one or more of: fibers, bumps, hemispherical protrusions and beads.

10 20. A method according to any one of claims 7 to 14 comprising installing, between the first slip membrane and the second structure, a third slip membrane.

21. A method according to claim 20 comprising bonding the third membrane to the second structure.

15

22. A method according to any one of claims 20 to 21, wherein the third slip membrane comprises a fourth plurality of raised elements adapted to reduce frictional forces against the first slip membrane.

20 23. A method according to claim 22, wherein the fourth plurality of raised elements is adapted to break surface tension in fluid trapped between the first and third slip membranes.

24. A method according to any one of claims 20 to 23 wherein the third slip
25 membrane is formed of one or more of the following materials: textile, foam, polypropylene, polyethylene, silicone, ceramics, metal.

25. Apparatus for permitting relative slideable movement between a first structure and a second structure, the apparatus comprising:

30 a first slip membrane installable between the first and second structures;

wherein the first slip membrane is formed of a first material, selected such that a coefficient of friction between the first and second structures is less than a first threshold value.

5 26. Apparatus according to claim 25, wherein, the first slip membrane comprises first and second opposed sides, the first side more proximate to the second structure than is the second side, and the second side more proximate to the first structure than is the first side, wherein the first side comprises a first plurality of raised elements adapted to reduce frictional forces against the second structure.

10

27. Apparatus according to claim 26, wherein the first plurality of raised elements is adapted to break surface tension in fluid trapped between the first slip membrane and the second structure.

15 28. Apparatus according to claim 27 wherein the second side comprises a second plurality of raised elements adapted to reduce frictional forces against the first structure.

20 29. Apparatus according to claim 28, wherein the second plurality of raised elements is adapted to break surface tension in fluid trapped between the first slip membrane and the first structure.

30. Apparatus according to any one of claims 25 to 27 wherein the first slip membrane is bonded to the first structure.

25 31. Apparatus according to any one of claims 25 to 29 comprising a second slip membrane installable between the first slip membrane and the first structure.

32. Apparatus according to claim 31 wherein the second slip membrane is adapted to fill in surface irregularities on the first structure.

30

33. Apparatus according to any one of claims 31 to 32 wherein the second slip membrane is bonded to the first structure.

34. Apparatus according to any one of claims 31 to 33 wherein the first and second
5 slip membranes are chemically incompatible.

35. Apparatus according to any one of claims 31 to 34 comprising lubricant material between the first and second slip membranes.

10 36. Apparatus according to any one of claims 31 to 35, wherein the second slip membrane comprises a third plurality of raised elements adapted to reduce frictional forces against the first slip membrane.

37. Apparatus according to claim 36, wherein the third plurality of raised elements is
15 adapted to break surface tension in fluid trapped between the first and second slip membranes.

38. Apparatus according to any one of claims 31 to 37 wherein the second slip membrane is formed of one or more of the following materials: textile, foam,
20 polypropylene, polyethylene, silicone, ceramics, metal.

39. Apparatus according to any one of claims 25 to 38 wherein the first slip membrane is formed of one or more of the following materials: textile, foam, polypropylene, polyethylene, silicone, ceramics, metal.
25

40. Apparatus according to any one of claims 25 to 39 wherein the first structure comprises a curable material.

41. Apparatus according to any one of claims 24 to 40 wherein the first structure
30 comprises an interior wall of a concrete-reinforced bore.

42. Apparatus according to any one of claims 26 to 29 wherein the first plurality of elements comprises one or more of: fibers, bumps, hemispherical protrusions and beads.

43. Apparatus according to any one of claims 28 to 29 wherein the second plurality of
5 elements comprises one or more of: fibers, bumps, hemispherical protrusions and beads.

44. Apparatus according to any one of claims 31 to 38 comprising a third slip membrane installable between the first slip membrane and the second structure.

10 45. Apparatus according to claim 44 wherein the third membrane is bonded to the second structure.

46. Apparatus according to any one of claims 44 to 45, wherein the third slip membrane comprises a fourth plurality of raised elements adapted to reduce frictional
15 forces against the first slip membrane.

47. Apparatus according to claim 46, wherein the fourth plurality of raised elements is adapted to break surface tension in fluid trapped between the first and third slip membranes.

20

48. Apparatus according to any one of claims 44 to 47 wherein the third slip membrane is formed of one or more of the following materials: textile, foam, polypropylene, polyethylene, silicone, ceramics, metal.

25 49. A method for permitting relative slideable movement between first and second structures, the method comprising:

installing between the first and second structures a first slip membrane; and

installing, between the first slip membrane and the first structure, a second slip membrane, wherein the second slip membrane is adapted to fill in surface irregularities
30 on the first structure.

50. A method according to claim 49, wherein the first slip membrane comprises first and second opposed sides, the first side more proximate to the second structure than is the second side, and the second side more proximate to the first structure than is the first side, wherein the second side comprises a first plurality of raised elements adapted to reduce frictional forces against the second slip membrane.

51. A method according to claim 50, wherein the first plurality of raised elements is adapted to break surface tension in fluid trapped between the first and second slip membranes.

52. A method according to any one of claims 49 to 51 wherein the second slip membrane comprises compressible material.

53. A method according to any one of claims 49 to 52 wherein the first and second slip membranes are chemically incompatible.

54. A method according to any one of claims 49 to 53 comprising bonding the second slip membrane to the first structure.

55. A method according to any one of claims 49 to 54 comprising installing a third slip membrane between the first slip membrane and the second structure.

56. A method according to claim 55 comprising bonding the third slip membrane to the second structure.

57. A method according to any one of claims 55 to 56 wherein the first and third slip membranes are chemically incompatible.

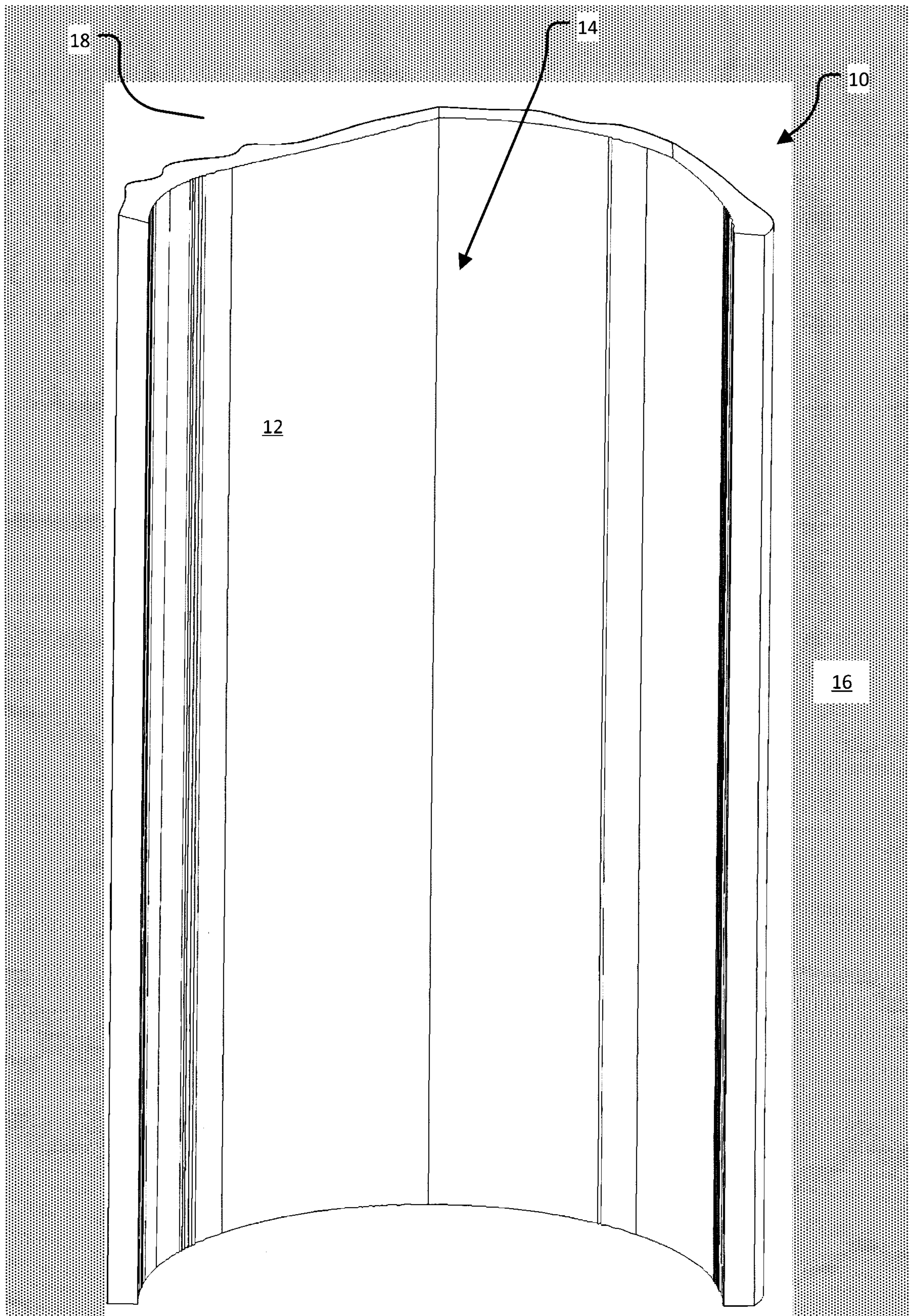


FIGURE 1A

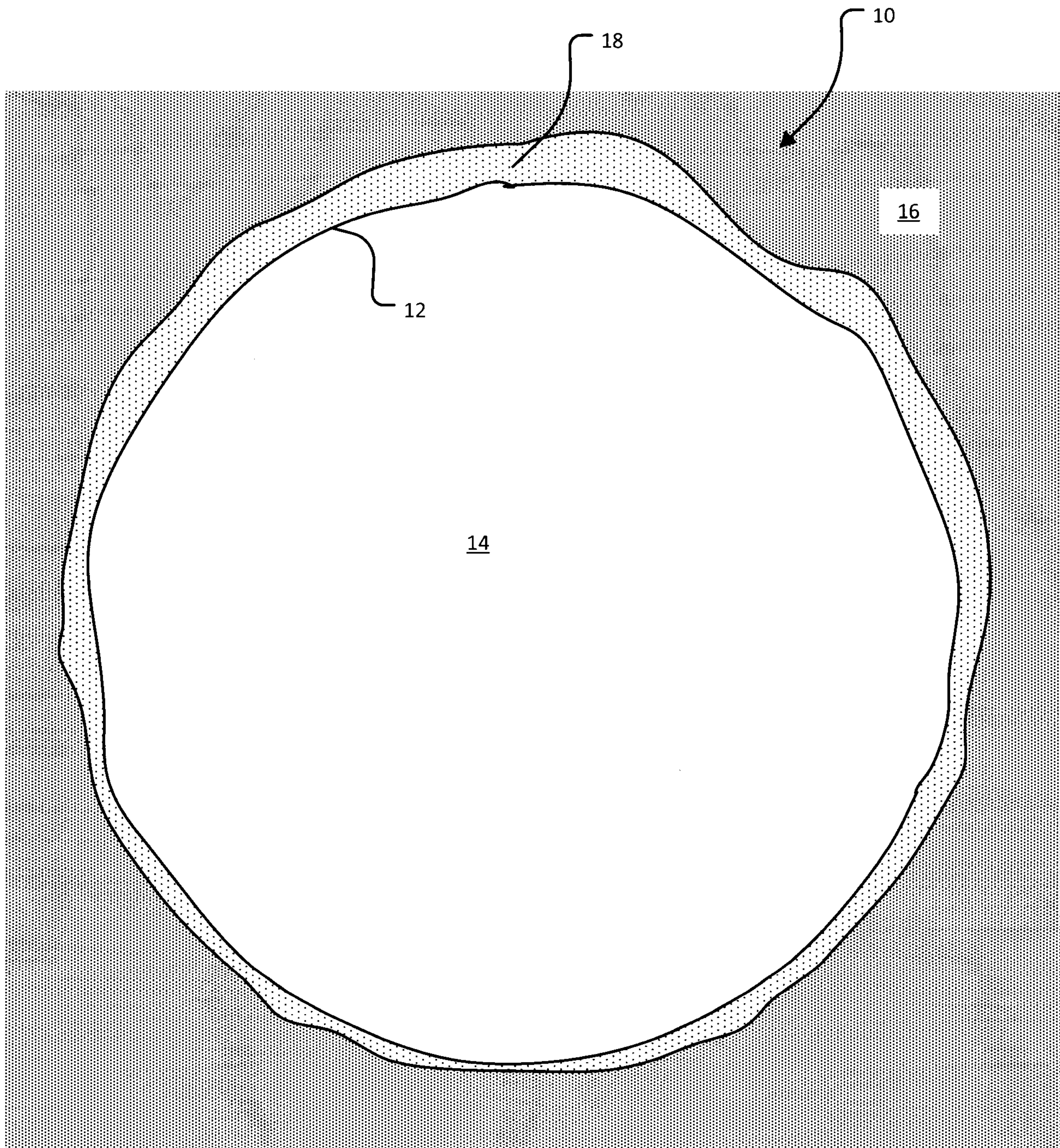


FIGURE 1B

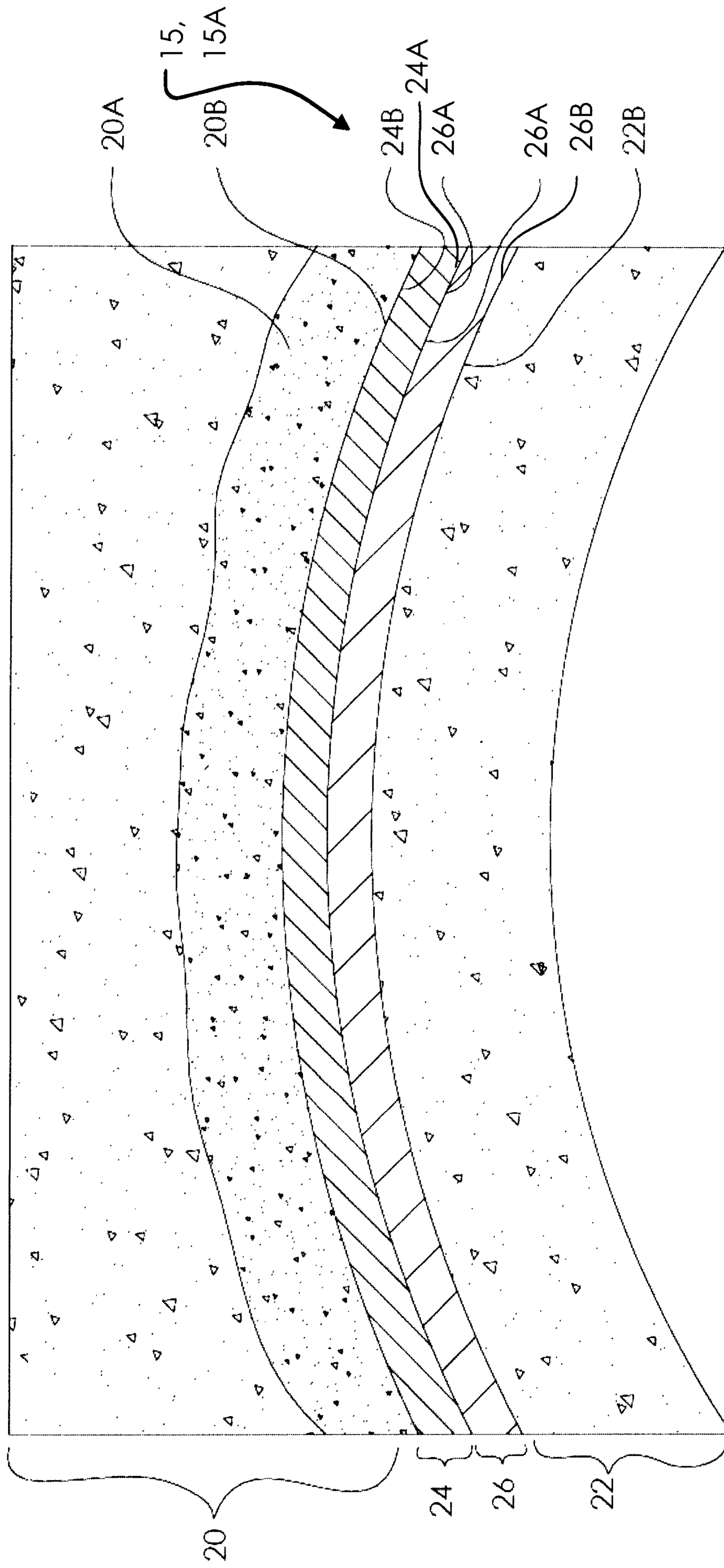


FIGURE 2

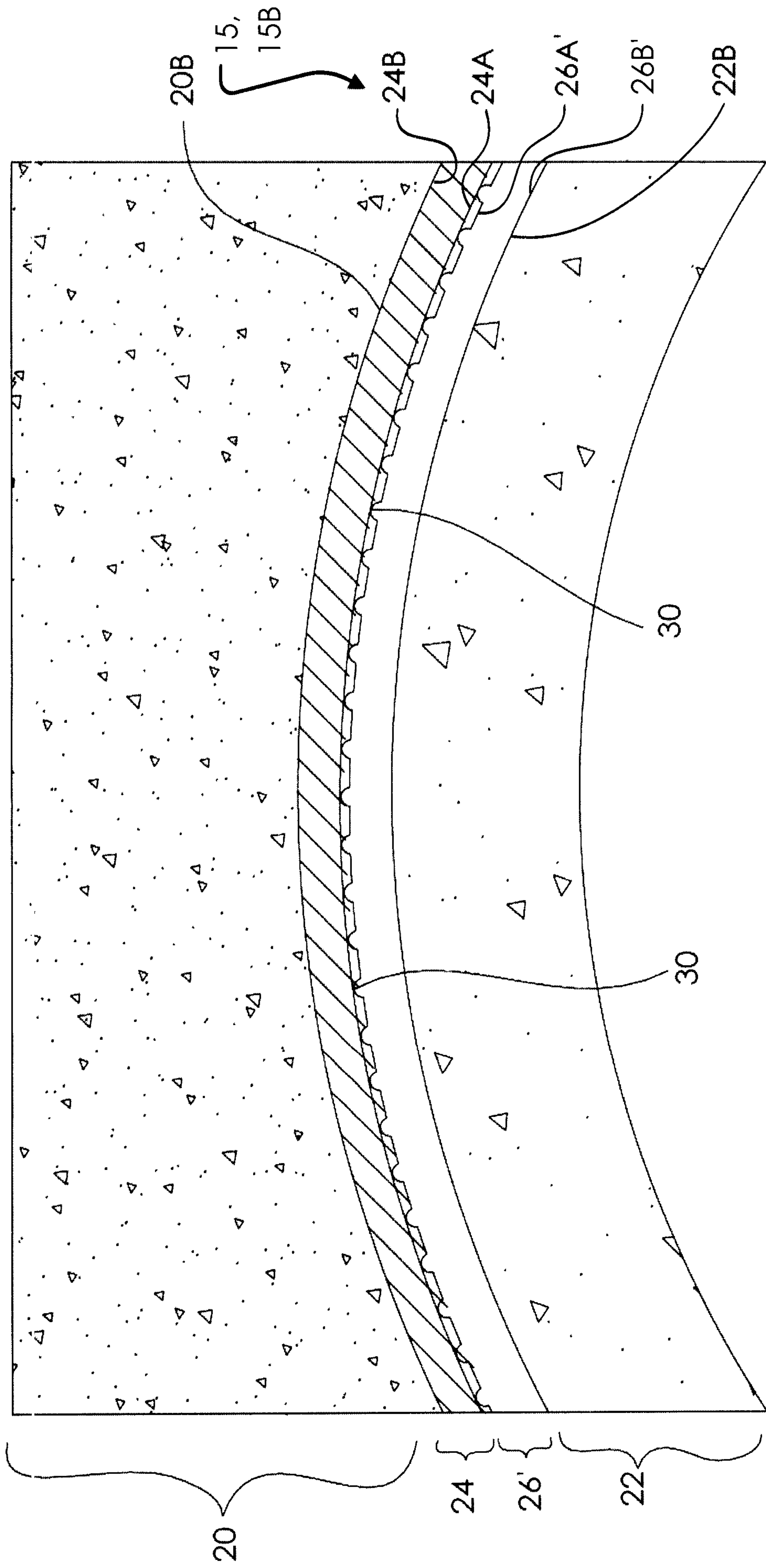


FIGURE 3

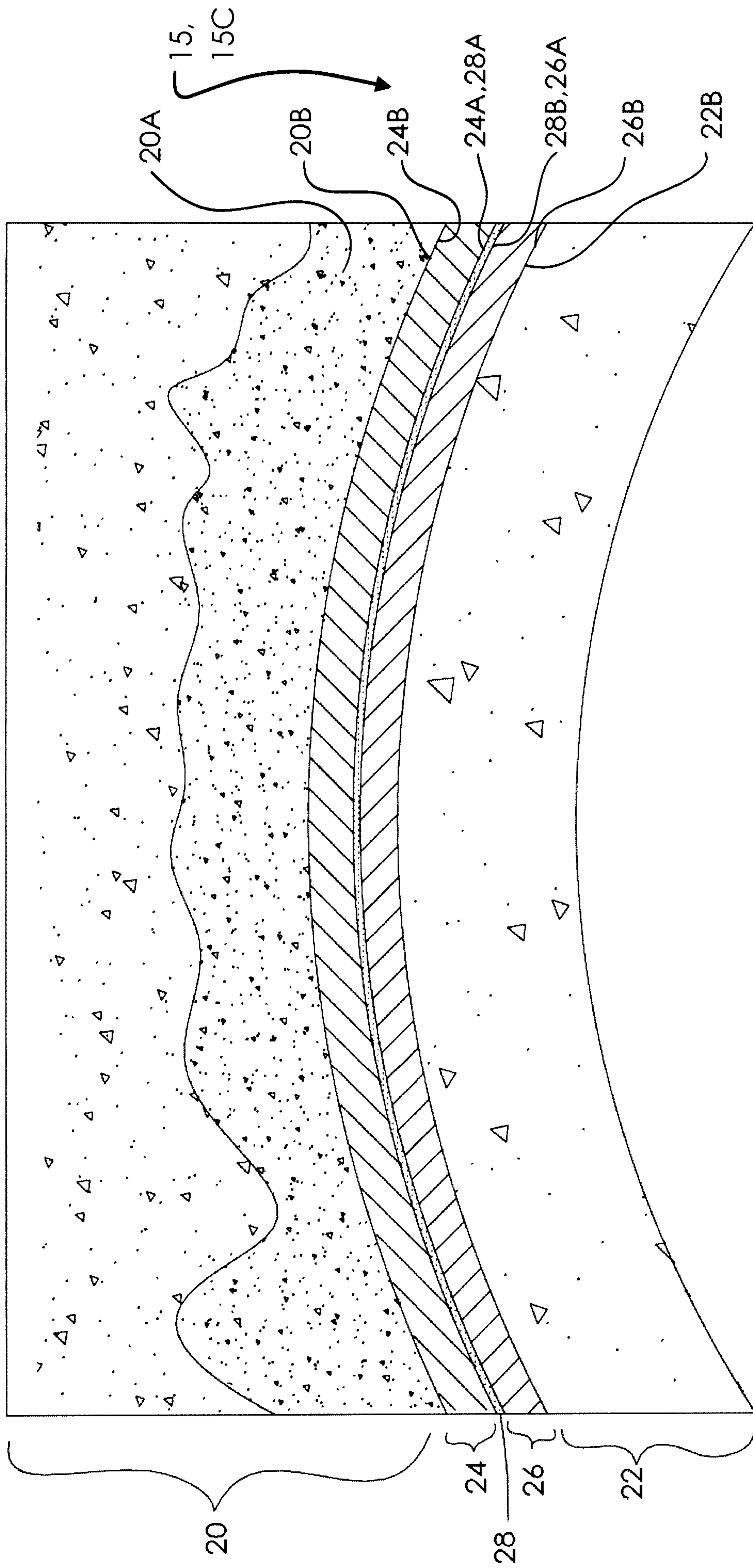


FIGURE 4

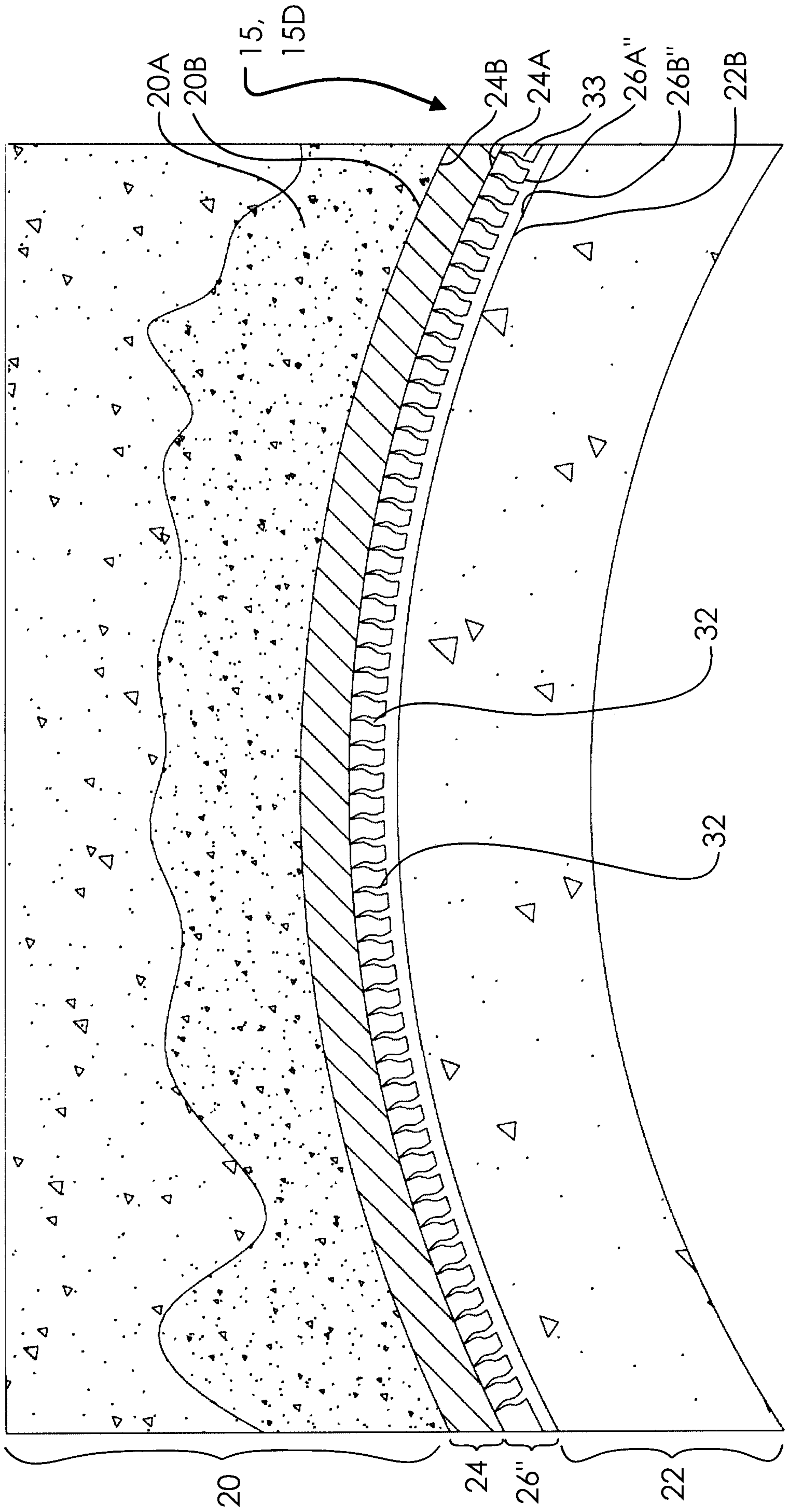


FIGURE 5

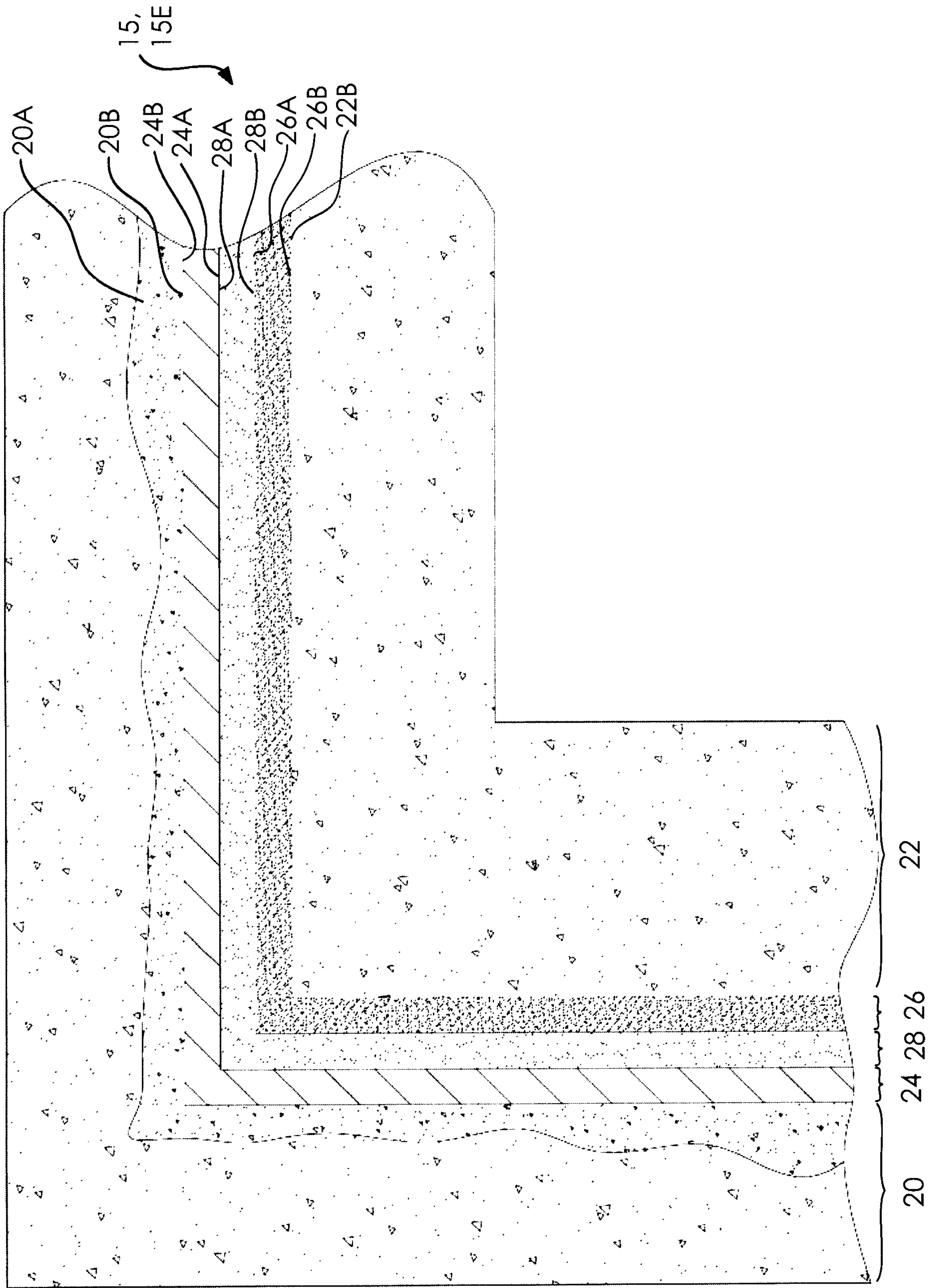


FIGURE 6

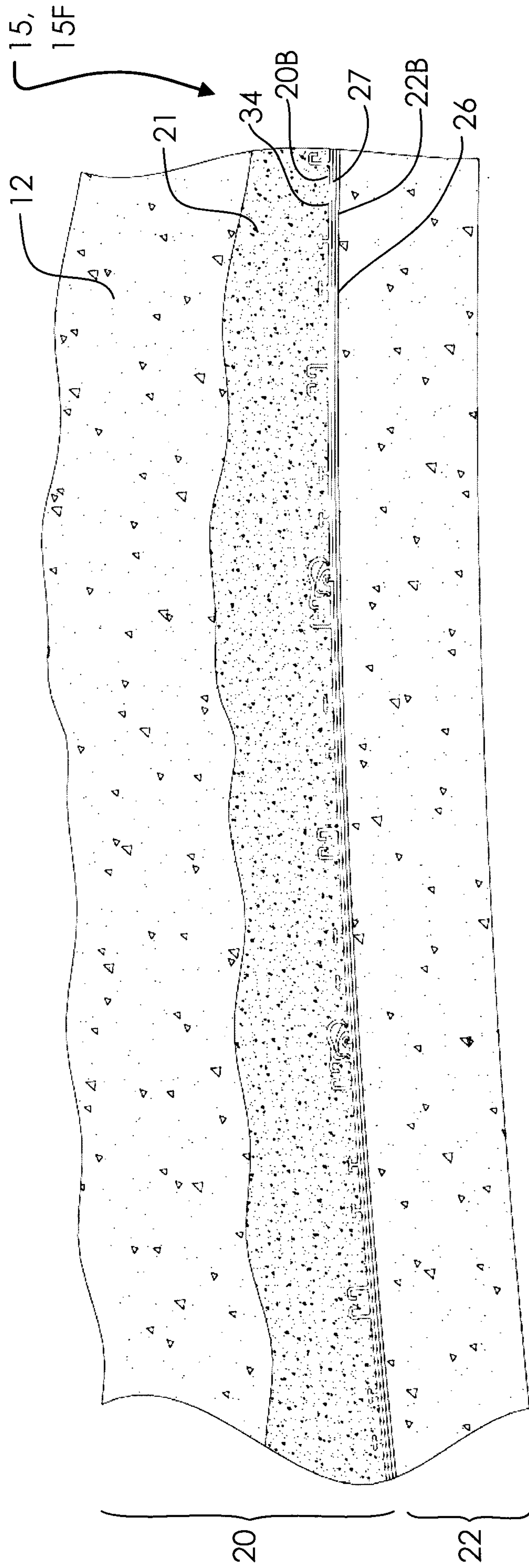


FIGURE 7

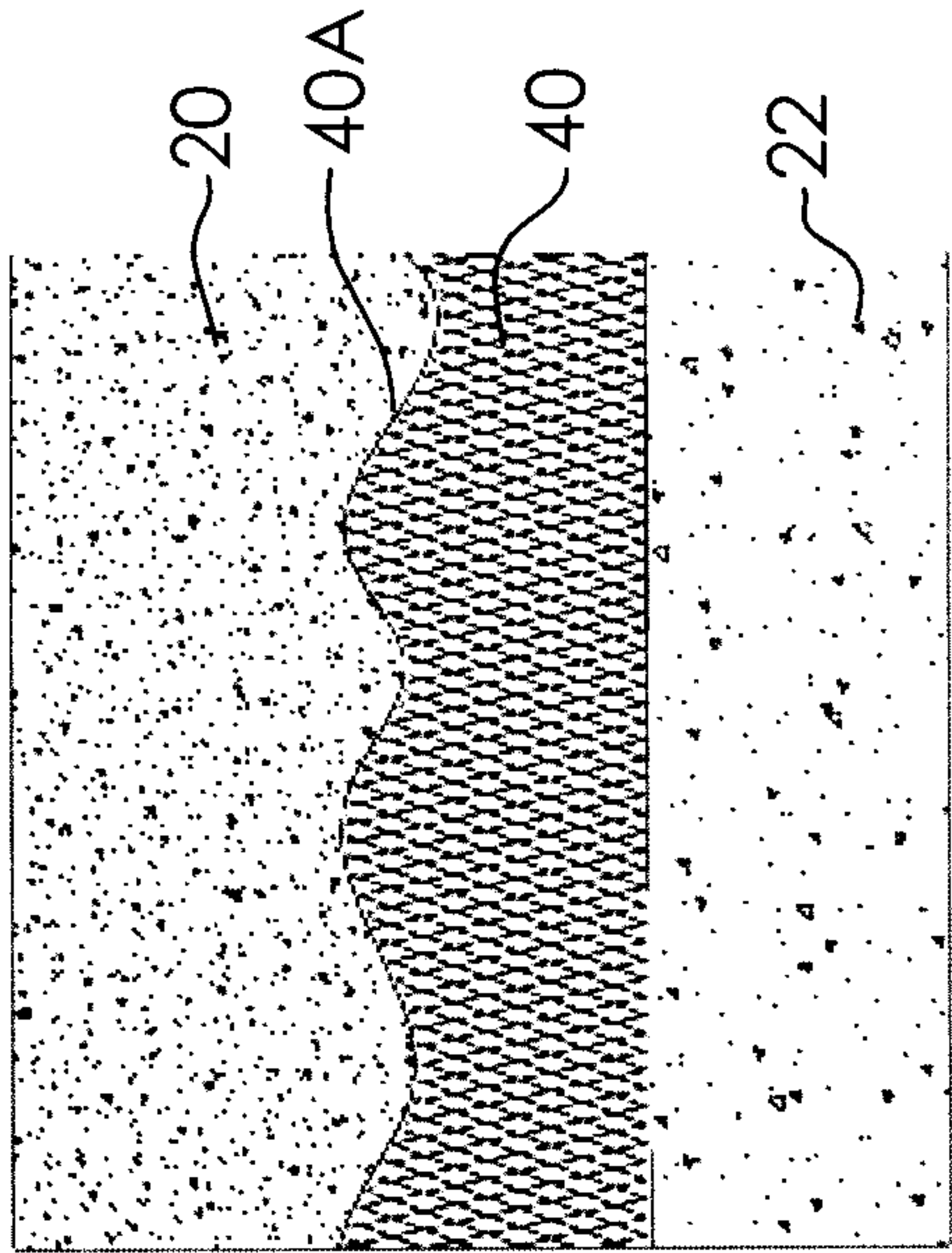


FIGURE 8A

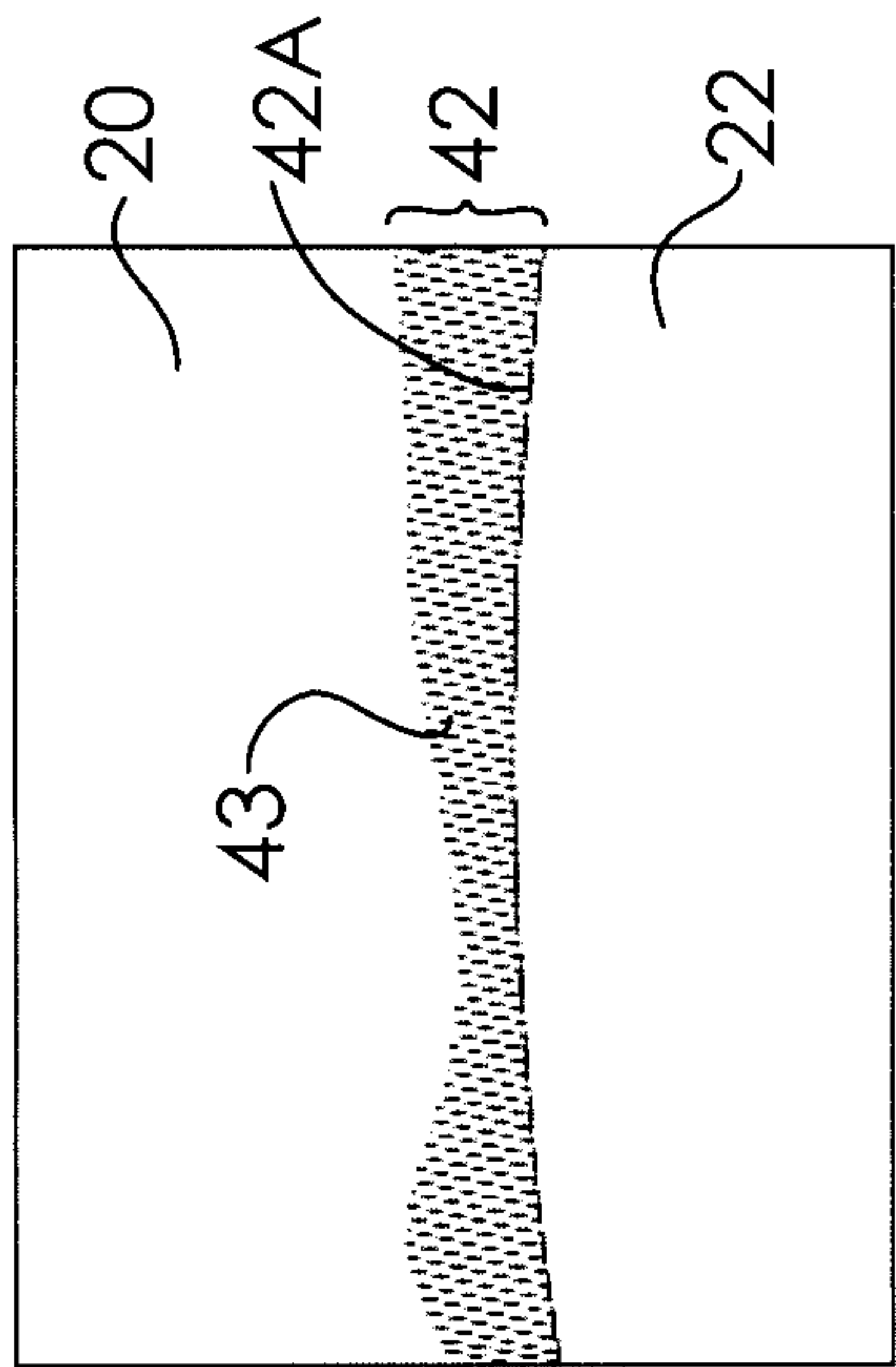


FIGURE 8B

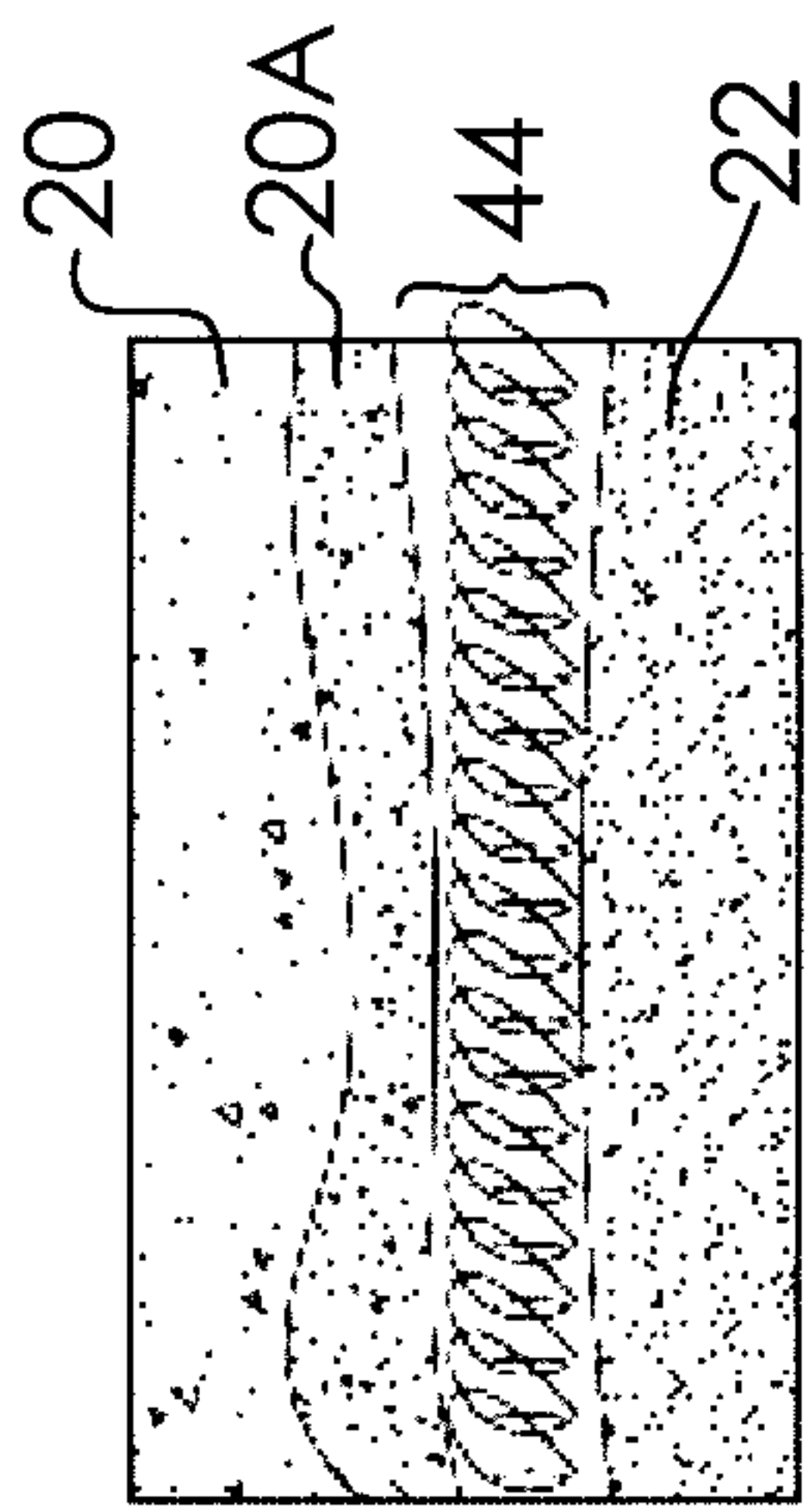


FIGURE 8C

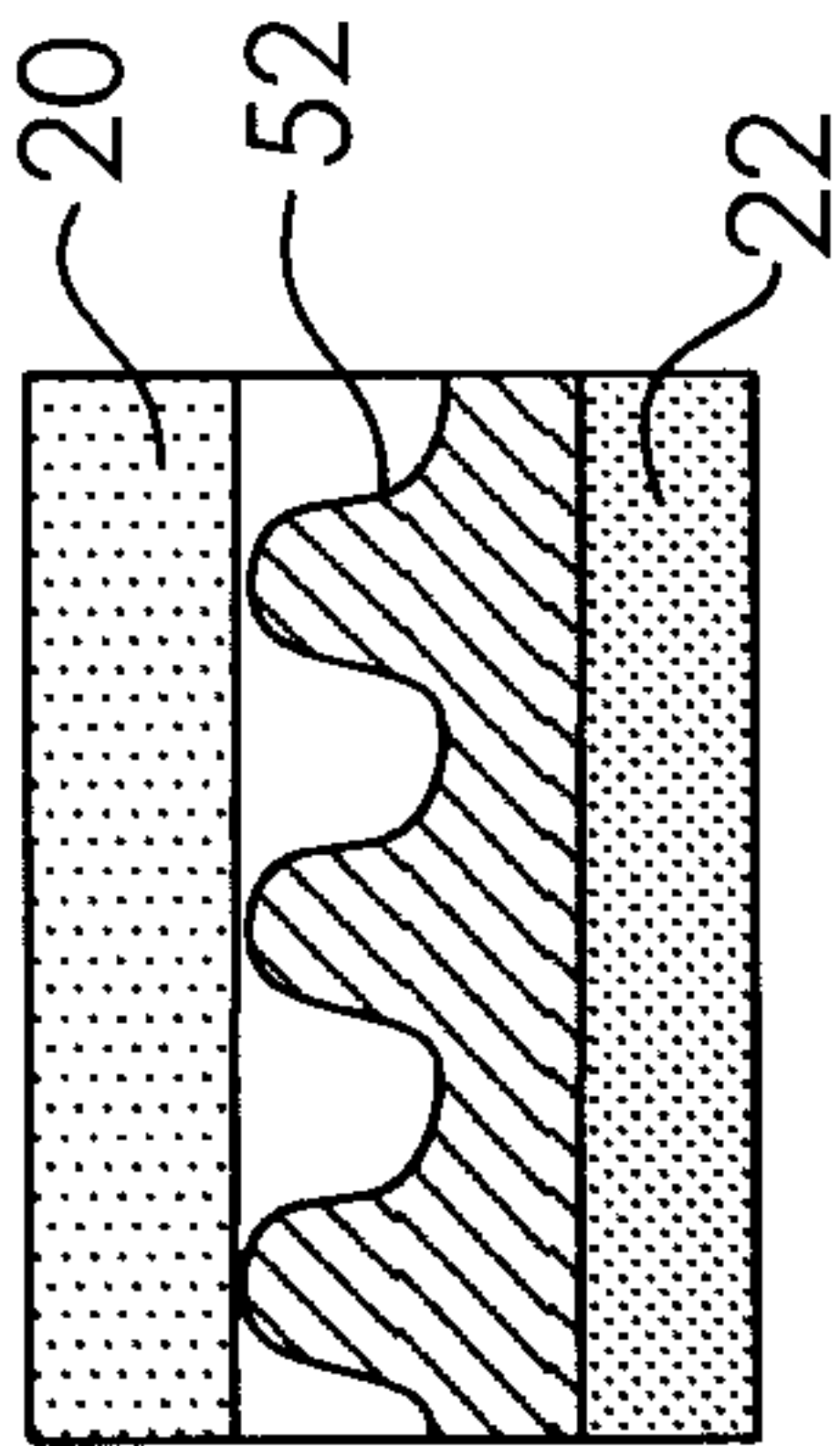


FIGURE 8D

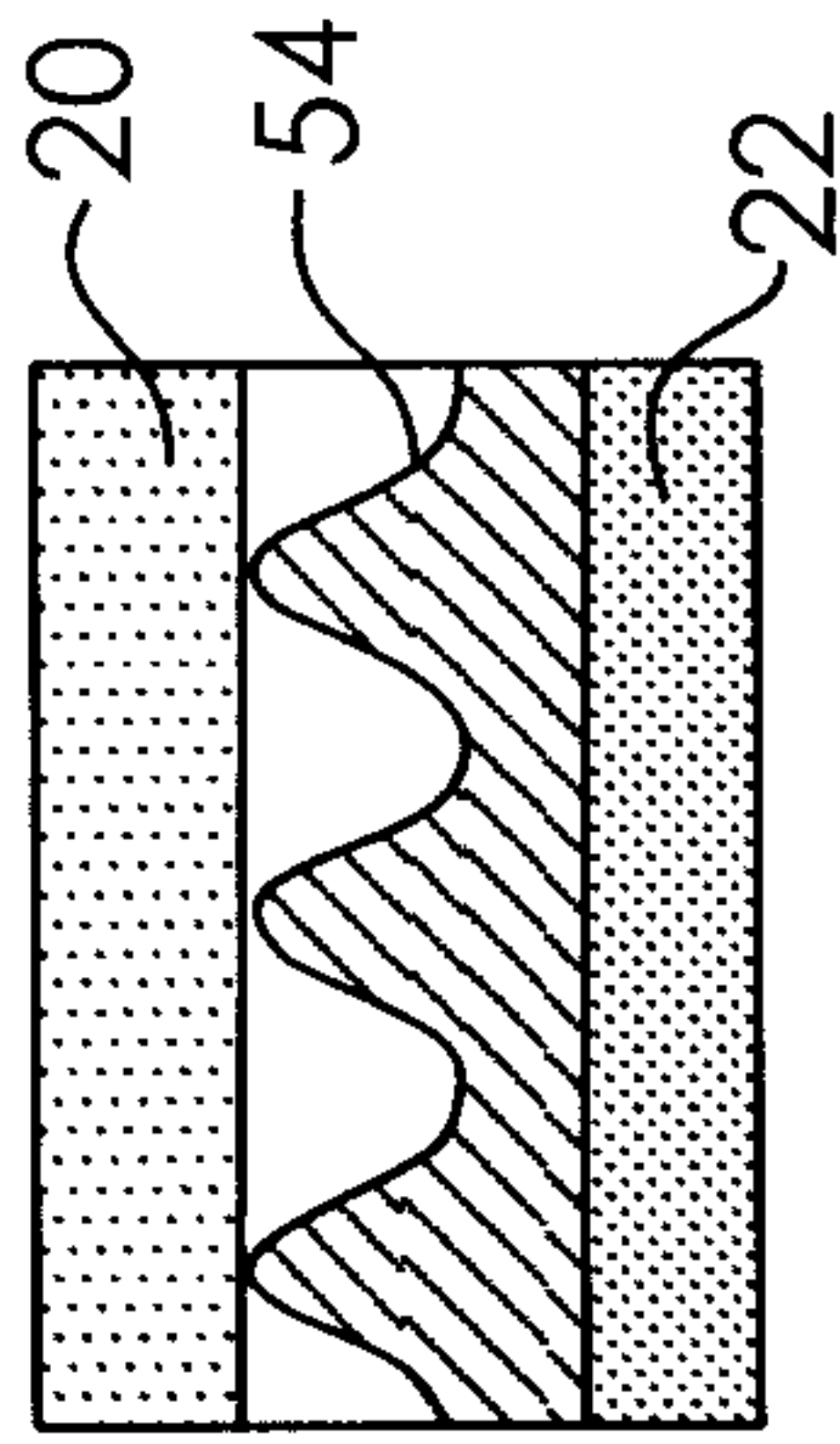


FIGURE 8E

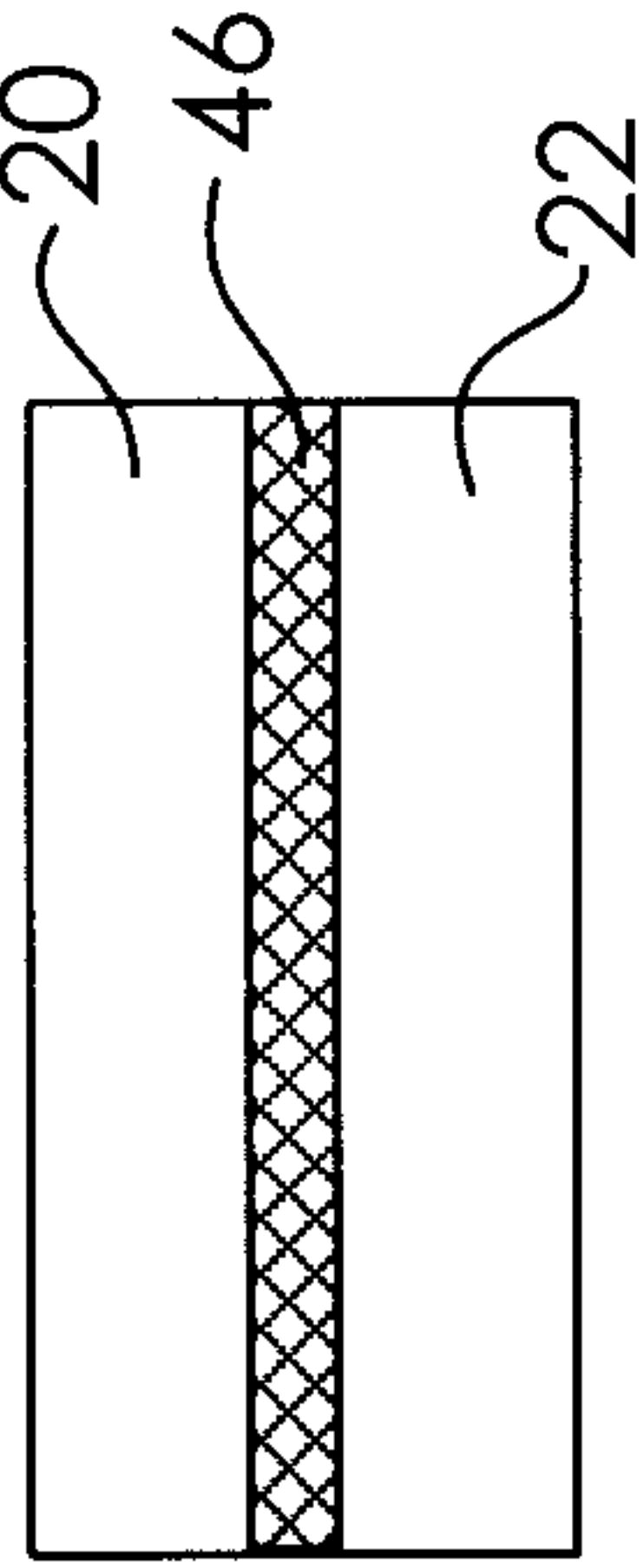


FIGURE 8F

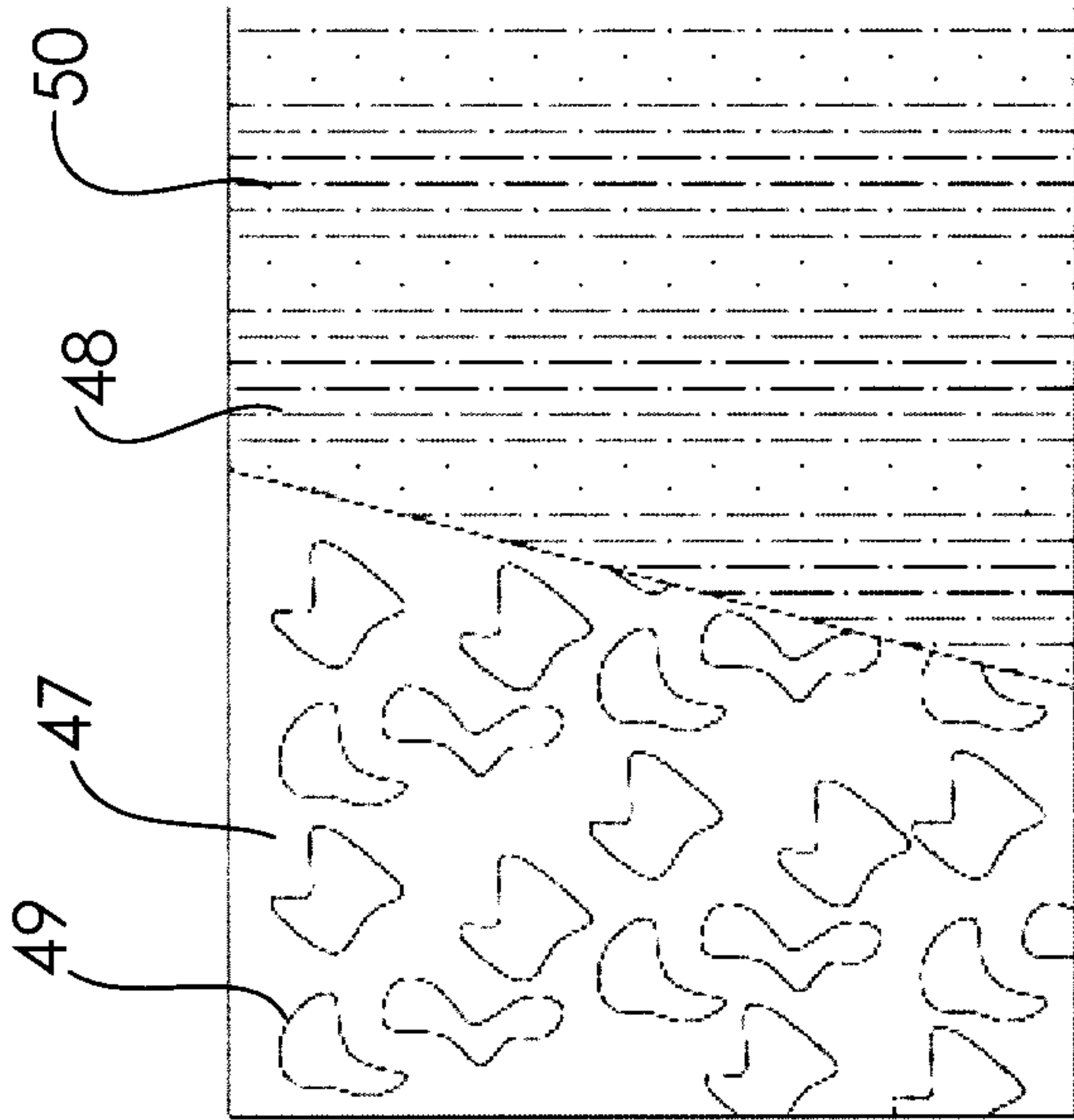


FIGURE 8G

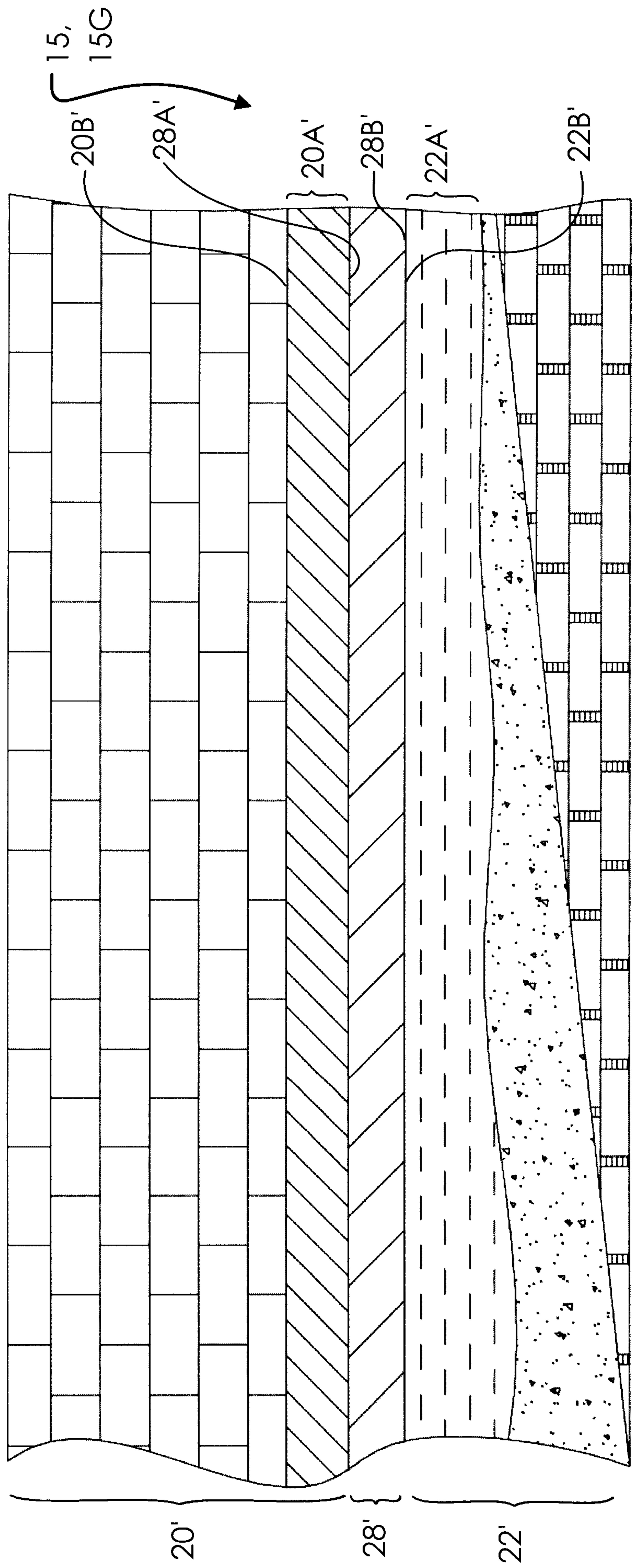


FIGURE 9

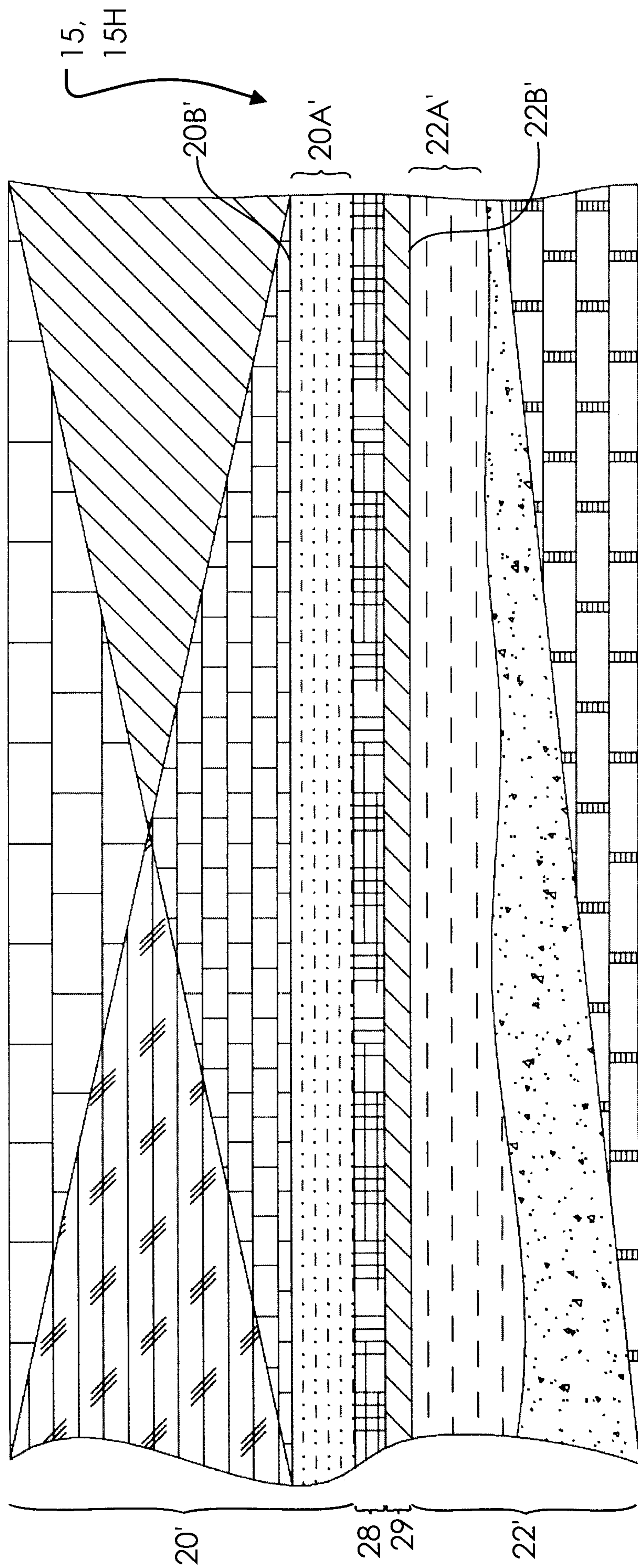


FIGURE 10

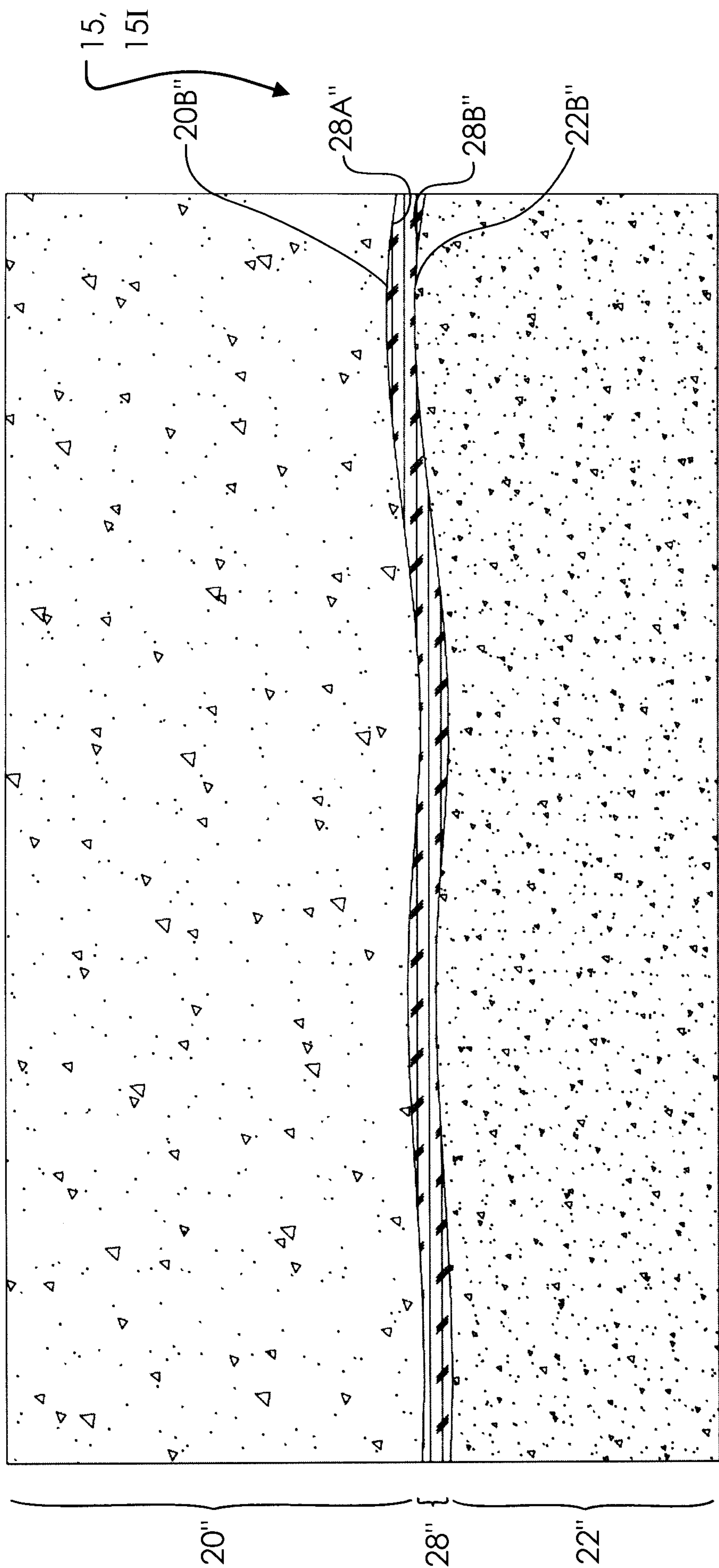


FIGURE 11

