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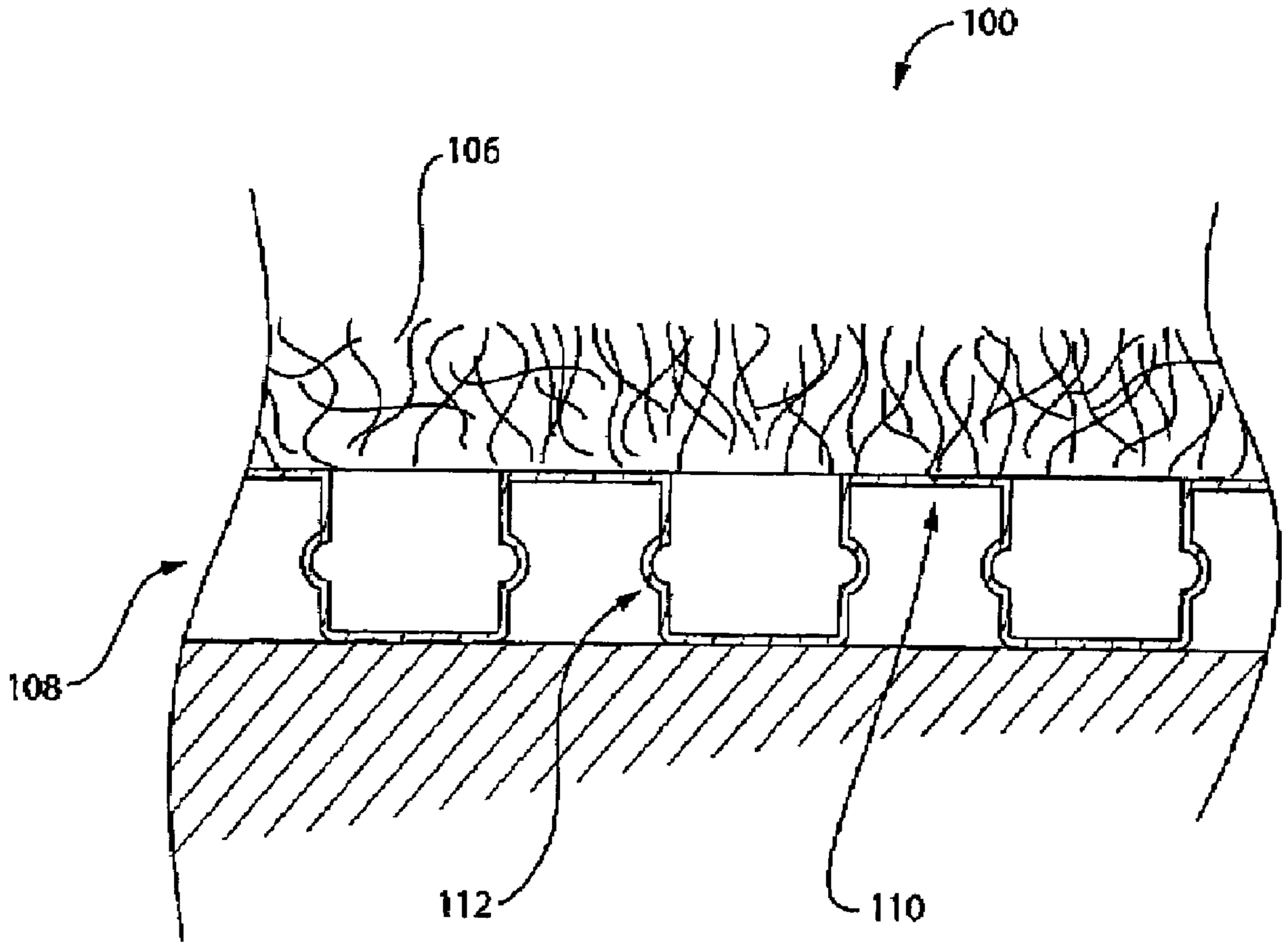
(54) Title: GREEN ROOFING SYSTEM INCLUDING DIMPLED ANCHOR LAYER



(57) Abrégé/Abstract:
A roofing panel includes a carrier comprising a web with an upper surface; a plurality of water retention compartments provided in the web and depending generally downwardly from the upper surface of the web; an anchor layer overlying at least a portion of the

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(57) Abrégé(suite)/Abstract(continued):
upper surface of the web, the anchor layer having an underside surface generally bearing against the upper surface of the web; and a plurality of dimples provided in the anchor layer, each of the dimples comprising a protruding portion extending generally downwardly from the underside surface of the anchor layer, each protruding portion adapted to nest at least partially within a respective one of the water retention compartments.

ABSTRACT

A roofing panel includes a carrier comprising a web with an upper surface; a plurality of water retention compartments provided in the web and depending generally downwardly from the upper surface of the web; an anchor layer overlying at least a portion of the upper surface of the web, the anchor layer having an underside surface generally bearing against the upper surface of the web; and a plurality of dimples provided in the anchor layer, each of the dimples comprising a protruding portion extending generally downwardly from the underside surface of the anchor layer, each protruding portion adapted to nest at least partially within a respective one of the water retention compartments.

TITLE: GREEN ROOFING SYSTEM INCLUDING DIMPLED ANCHOR LAYER

FIELD

[0001] The present invention relates to the field of green roofing. More particularly, the invention relates to apparatus, systems and methods for green roofing in which a dimpled anchor layer is provided

BACKGROUND

[0002] Green roofing involves the installation of green space on the rooftops of buildings and on other structures. A green roof extends the lifespan of traditional roofing materials, reduces building cooling and heating energy costs, manages storm water runoff, improves air quality, and creates a more esthetically pleasing environment.

[0003] Notwithstanding the benefits of green roofing, there has been relatively little prior development in the field. A typical green roof includes a waterproof membrane disposed on the surface of a roof, a drainage layer comprising gravel or another suitable material, a filter membrane, growth medium that may be loose or contained, for example, in a mat made of rock wool, and vegetation such as herbs, grasses, mosses, wild plants and flowers, and other plants.

[0004] Typically, a green roof is installed directly on the surface of a roof. There are several problems associated with these current technologies. The vegetation of green roofs installed directly on the surface of a roof is typically grown from seed on the roof after the other components of the green roof are installed. This growing period results in increased maintenance costs, loss of growth medium from wind erosion and other natural forces, and delays the realization of benefits from the green roof. Green roofs installed in this fashion are also typically permanent fixtures and, as such, render repairs to the underlying roof very expensive. In addition to these problems, green roofs installed directly on the surface of a roof typically lack water retention means other than those inherent in the vegetation and growth medium. This results in less efficient management of storm water runoff, as well as

increasing the maintenance required by the green roof during dry seasons, such as watering.

[0005] Thus, there is a need for an improved green roofing apparatus, system, and method.

SUMMARY

[0006] In a broad aspect of the invention, there is provided a roofing panel comprising a carrier having a web with a top portion, an anchor layer positioned adjacent the top portion of the web, and a plurality of water retention compartments formed in the web.

[0007] In another broad aspect of the invention the anchor layer is affixed to the top portion of the web.

[0008] In another broad aspect of the invention, there is provided a roofing system comprising a plurality of roofing panels installed on an underlying surface. Each of the roofing panels comprises a carrier having a web with a top portion, an anchor layer positioned adjacent the top portion of the web, and a plurality of water retention compartments formed in the web.

[0009] In another broad aspect of the invention the anchor layer of each roofing panel of the system is affixed to the to the top portion of the web of the roofing panel.

[0010] According to another aspect, a roofing panel includes a carrier having a web with an upper surface; a plurality of water retention compartments provided in the web and depending generally downwardly from the upper surface of the web; an anchor layer overlying at least a portion of the upper surface of the web, the anchor layer having an underside surface generally bearing against the upper surface of the web; and a plurality of dimples provided on the anchor layer, each of the dimples comprising a protruding portion extending generally downwardly from the underside surface of the anchor layer, the protruding portions adapted to be received at least partially within respective ones of the water retention compartments.

[0011] The dimples can be positioned on the anchor to correspond to positions of the water retention compartments on the web, such that the

protruding portions of at least a first group of the dimples nest inside a first group of the water retention compartments. The water retention compartments can be positioned on the web in a repeating pattern. The protruding portions can be shaped to correspond to an interior surface of the water retention compartments in which the protruding portions are nested. The protruding portions can extend to a sufficient depth within the water retention compartments to generally abut a lower surface of the water retention compartments.

[0012] Each of the dimples can comprises a base and a sidewall extending from the underside of the anchor layer to the base. The dimples can be generally circular in shape when viewed from above, the dimples each having a diameter between 1 cm and 25 cm, and a depth between 0.1 cm and 10 cm. Each dimple can have an interior defining a recess in a top surface of the anchor, the top surface disposed opposite the underside surface. Each recess in the dimples can define a sump, and the carrier can further comprises drainage holes, the drainage holes being located away from the sump.

[0013] The anchor layer can comprise intertwined fibers, and the sidewall of each of the dimples can have a lower intertwined fiber density than other portions of the anchor layer. The anchor layer can further comprise pre-grown vegetation, the pre-grown vegetation being grown at a site remote from the site of installation of the roofing panel.

[0014] According to another aspect, a method of producing a roofing panel comprising the steps of: placing a blank anchor layer in a stamping machine, wherein the stamping machine comprises: a first plate comprising a plurality of male heads, and a second plate comprising a plurality of female wells, the male heads and female wells being aligned such that the male heads are receivable within the female wells, the blank anchor layer being placed between the first plate and the second plate; and forming a plurality of dimples in the blank anchor layer by closing the first plate and the second plate together such that the male heads align with the female wells.

[0015] The method can include the step of laying the blank anchor layer on an upper surface of a carrier, the carrier comprising a web, and a plurality of water retention compartments formed in the web, wherein a first group of the dimples nest inside a first group of the water retention compartments. The step of forming the dimples can include pressing an underside of the blank anchor layer against the upper surface of the carrier. The method can include the step of placing an adhesive on at least one of an underside surface of the blank anchor layer and the upper surface of the carrier. The method can include the step of curing the adhesive.

[0016] According to another aspect, a roofing system includes a plurality of roofing panels, each of the plurality of roofing panels comprising: a carrier comprising a web with an upper surface; a plurality of water retention compartments provided in the web and depending generally downwardly from the upper surface; an anchor layer overlying at least a portion of the upper surface of the web such that an underside of the anchor layer at least partially contacts the upper surface of the web; and a plurality of dimples formed in the anchor layer, wherein each of the dimples comprises a protruding portion extending from an underside of the anchor layer, wherein at least one of the protruding portions nests inside at least one of the water retention compartments.

[0017] The plurality of roofing panels can include: a first roofing panel with a first group of water retention compartments located laterally adjacent a first edge of the carrier of the first roofing panel; a second roofing panel with a second group of water retention compartments located laterally adjacent a second edge of the carrier of the second roofing panel; and wherein the first group of water retention compartments nests within the second group of water retention compartments. A first group of the dimples on the anchor layer of one of the first roofing panel or the second roofing panel can be nested inside the first group of water retention compartments. The water retention compartments and the dimples can be provided in a repeating pattern to allow nesting of a first group of water retention compartments of a first roofing panel inside a second group of water retention compartments of a second roofing panel.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] Figure 1 is a top view of a green roofing panel.

[0019] Figure 2 is a cross-sectional view of a green roofing panel.

[0020] Figure 3 is a top view of another embodiment of a green roofing panel.

[0021] Figure 4 is a top view of another embodiment of a green roofing panel.

[0022] Figure 5 is a top view of another embodiment of a green roofing panel.

[0023] Figure 6 is a perspective view of another embodiment of a green roofing panel.

[0024] Figure 7 is a cross-sectional view of another embodiment of a green roofing panel.

[0025] Figure 8 is a top view of a green roofing panel having drainage means.

[0026] Figure 9 is a cross-sectional view of a green roofing panel having drainage means.

[0027] Figure 10 is a perspective view of an embodiment of a carrier.

[0028] Figure 11 is a perspective view of an embodiment of a carrier.

[0029] Figure 12 is a top view of a green roofing panel having drains.

[0030] Figure 13 is a perspective view of a drain.

[0031] Figure 14 is a cross-sectional view of interlocking water retention compartments.

[0032] Figure 15 is a cross-sectional view of interlocking water retention compartments.

[0033] Figure 16 is a perspective view of a water retention compartment.

[0034] Figure 17 is a perspective view of another embodiment of a water retention compartment.

[0035] Figure 18 is a cross-sectional view of nesting water retention compartments.

[0036] Figure 19 is a cross-sectional view of nesting water retention compartments.

[0037] Figure 20 is a top view of another embodiment of a carrier.

[0038] Figure 21 is a cross-sectional view of a green roofing panel having a filter.

[0039] Figure 22 is a top view of a green roofing system.

[0040] Figure 23 is a cross-sectional view of a green roofing system.

[0041] Figure 24 is a perspective view of an embodiment of a green roofing system.

[0042] Figure 25 is a cross-sectional view of an installed green roofing system.

[0043] Figure 26 is a perspective view of an embodiment of a green roofing system.

[0044] Figure 26B is a cross-sectional view of an embodiment of a green roofing system.

[0045] Figure 27 is a cross-sectional view of an edge detail.

[0046] Figure 28 is a cross-sectional view of a green roofing system installed with an edge detail.

[0047] Figure 29 is a top view of an embodiment of a green roofing system.

[0048] Figure 30 is a cross-sectional view of an embodiment of a green roofing system.

[0049] Figure 31 is a cross-sectional view of an embodiment of a green roofing system.

[0050] Figure 32 is a cross-sectional view of an embodiment of a green roofing system.

[0051] Figure 33 is a cross-sectional view of an embodiment of a green roofing system.

[0052] Figure 34 is a cross-sectional view of an embodiment of a green roofing system.

[0053] Figure 35 is a cross-sectional view of an embodiment of a green roofing system.

[0054] Figure 36 is a cross-sectional view of an embodiment of a green roofing system.

[0055] Figure 37 is a cross-sectional view of an embodiment of a green roofing system.

[0056] Figure 38 is a cross-sectional view of a green roofing system installed with a tension system.

[0057] Figure 39 is a perspective view of an embodiment of a green roofing system.

[0058] Figure 39B is a perspective view of an embodiment of a green roofing system.

[0059] Figure 39C is a cross-sectional view of an embodiment of a green roofing system.

[0060] Figure 40 is a top view of a green roofing system with irrigation means.

[0061] Figure 41 is a cross-sectional view of a green roofing system with irrigation means.

[0062] Figure 42 is a side view of a bracket.

[0063] Figure 43 is a top view of a green roofing system with irrigation means and sprinklers.

[0064] Figure 44 is a perspective view of an embodiment of a green peak attachment adapter.

[0065] Figure 45 is a perspective view of an embodiment of a green roofing system.

[0066] Figure 46 is a cross-sectional view of an embodiment of a green roofing system.

[0067] Figure 47 is a perspective view of an embodiment of a green roofing system.

[0068] Figure 48 is a cross-sectional view of an embodiment of a green roofing system having an anchor with dimples.

[0069] Figure 49 is a cross-sectional view of an embodiment of a green roofing system having an anchor with dimples and vegetation growing from the anchor.

[0070] Figure 50 is a perspective view of a stamping tool for making a roofing panel or portions thereof.

[0071] Figure 51 is a cross sectional view of a portion of the tool of Figure 50 shown in a closed position.

[0072] Figure 52 is a perspective view of another embodiment of a roofing panel.

DETAILED DESCRIPTION

[0073] Various apparatuses or processes will be described below to provide an example of an embodiment of each claimed invention. No embodiment described below limits any claimed invention and any claimed invention may cover processes or apparatuses that are not described below. The claimed inventions are not limited to apparatuses or processes having all of the features of any one apparatus or process described below or to features common to multiple or all of the apparatuses described below. It is possible that an apparatus or process described below is not an embodiment of any claimed invention. The applicants, inventors or owners reserve all rights that they may have in any invention disclosed in an apparatus or process described below that is not claimed in this document, for example the right to claim such an invention in a continuing application and do not intend to abandon, disclaim or dedicate to the public any such invention by its disclosure in this document.

[0074] Reference is first made to Figures 1 and 2. Figure 1 is a top view of a green roofing panel 100 according to the present invention. Figure 2 is a cross-sectional view of a portion of panel 100 as viewed from the line 2-2. Panel 100 is shaped and sized in order to fit the area in which it is to be installed. Typically, panel 100 is rectangular having first sides 102 between 0.5m and 100m in length and second sides 104 between 0.5m and 4m in length. Panel 100 includes a carrier 108 and an anchor layer 106. Carrier 108 is formed of a web 110 with a plurality of water retention compartments 112 formed in web 110.

[0075] Typically, a system comprising several panels 100 is used to grow vegetation on the roof of a building. Vegetation is grown in anchor layer 106, and water retention compartments 112 serve to store water supplied to the system for consumption by vegetation.

[0076] As shown in Figures 1 and 2, anchor layer 106 is affixed to carrier 108. Anchor layer 106 can be affixed to carrier 108 by any suitable means including, but not limited to, chemical bonds, heat bonds, mechanical bonds, and mechanical fasteners such as rivets, stitching, clips, screws, nuts, or bolts, and combinations thereof. Anchor layer 106 is positioned on carrier 108 such that one or more water retention compartments 112 are left uncovered by anchor layer 106.

[0077] Reference is next made to Figure 3, which illustrates a panel 300 according to the invention. Panel 300 is similar to panel 100 and corresponding components are identified with similar reference numerals. Panel 300 has an anchor layer 306 positioned on a carrier 308 such that the anchor layer 306 is bordered by two rows of exposed water retention compartments 312 on all four sides.

[0078] Reference is next made to Figure 4, which illustrates a panel 400 according to the invention. Panel 400 is similar to panel 100 and corresponding components are identified with similar reference numerals. Panel 400 has an anchor layer 406 positioned on a carrier 408 such that anchor layer 406 is bordered by four rows of water retention compartments 412 on two adjacent sides.

[0079] Reference is next made to Figure 5, which illustrates a panel 500 according to the invention. Panel 500 is similar to panel 100 and corresponding components are identified with similar reference numerals. Panel 500 has an anchor layer 506 positioned on a carrier 508 such that all water retention compartments 512 are covered by anchor layer 506.

[0080] Typically, anchor layer 106 is porous sheet of regular or irregular three-dimensional mesh or screen. For example, anchor layer 106 may be a sheet of intertwined fibers, wire, or coated wire. Anchor layer 106 can be made of any suitable material including, but not limited to, plastics such as such as polyester, polyethylene, polyvinyl chloride, and polypropylene, wires made of metals such as steel and copper, organic materials such as hemp, rockwool, wood fibers, and coconut fibers, and combinations thereof.

[0081] Anchor layer 106 may have any dimensions suitable for a particular embodiment. In one embodiment, anchor layer 106 is between 0.1cm and 20cm thick.

[0082] Carrier 108 can be made of any suitable material including, but not limited to, rubber, and plastics such as polyester, polyethylene, polyvinyl chloride, polypropylene, and combinations thereof. In some embodiments, carrier 108 is made of a plastic that is sufficiently flexible such that panel 100 can be rolled by hand and cut with hand tools.

[0083] Reference is now made to Figures 6 and 7. Figure 6 is a perspective view of another embodiment of a green roofing panel 600 according to the present invention. Figure 7 is cross-sectional view of a portion of panel 600. Panel 600 is similar to panel 100 and corresponding components are identified with similar reference numerals.

[0084] As shown in Figure 6, an anchor layer 606 is affixed to a carrier 608 by rivets 614, but may be attached by other suitable fasteners such as plastic welding (shown at 615) stitching, clips, screws, nuts, or bolts, and combinations thereof, for example. In the embodiments shown in Figures 6 and 7, anchor layer 606 is made of a porous material of tightly intertwined fibers commonly referred to as rock wool. In use, anchor layer 606 provides a means for supporting the growth of vegetation. Typically, the roots of

vegetation propagate into, and become entangled in, anchor layer 606. By this, anchor layer 606 provides physical support to the vegetation. Anchor layer 606 also retains water and nutrients that are supplied to it and in turn supplies the water and nutrients to the vegetation. Anchor layer 606 may also be impregnated with a growth medium or covered in growth medium. Growth medium may be chosen from a variety of materials. For example, many soils, sands, and gravels may be used. As well, clay, gravel, fertilizer, peat, compost, super-absorbent polymers, and combinations thereof may be used in other embodiments, for example.

[0085] Plastic welding 615 is formed using a plastic injection welder such the Drader Injectiweld manufactured by Drader Injectiweld, Inc. of Edmonton, Canada. In practice, molten plastic such as polyethylene or polypropylene, for example, is injected into holes disposed in anchor layer 606 in fluid communication with carrier 610. Once the plastic has cured, anchor layer 606 and carrier 610 are connected by plastic weld 615.

[0086] In some embodiments, carrier 108 is water impermeable and has no dralnage means, it can act as a waterproofing layer.

[0087] Reference is now made to Figures 8 and 9, which illustrate various alternatives for carrier 108, shown at 808. Carrier 808 is similar to carrier 108 and corresponding components are identified with similar reference numerals. Carrier 808 has drainage means 816. Drainage means 816 can be on web 810, or in water retention compartments 812, or both. In some embodiments drainage means 816 are holes penetrated through web 810, or water retention compartments 812, or both. The location, number and dimensions of drainage means 816 are determined by design parameters such as climate, water or drainage requirements for the green roofing system, and the ability of the underlying roof to support the weight of water held by the green roofing system. For example, in wet climates, greater drainage can be accomplished with a greater number of holes or larger holes or both. The location of drainage means 816 in water retention compartments 812 also controls drainage. The closer drainage means 816 are to the bottom of water retention compartment 812 the less water will be retained.

[0088] Reference is now made to Figures 10 and 11, which illustrate perspective views of further embodiments of carrier 108, shown at 1008 and 1108 respectively, corresponding components are identified with similar reference numerals. Carriers 1008, 1108 have drainage means 1016, 1116, but are otherwise similar to carrier 108 and corresponding components are identifled with similar reference numerals.

[0089] Also shown in Figures 10 and 11 are different arrangements of rows of water retention compartments 1012, 1112. In the embodiment shown in Figure 11, the water retention compartments 1112 are arranged in a side-by-side configuration. In the embodiment shown in Figure 10, water retention compartments 1012 are arranged in a staggered configuration. In other embodiments, different arrangements are also possible, for example.

[0090] Reference is now made to Figures 12 and 13. Figure 12 illustrates a top view of another embodiment of green roofing panel 1200 having drains 1218. Panel 1200 is similar to panel 100 and corresponding components are identified with similar reference numerals. Figure 13 is a perspective view of drain 1218 with a cap 1219. Sections of panel 1200 are removed such that drains 1218 can be installed. The number, dimensions, and locations of drains 1218 are determined based on the expected precipitation. Drains 1218 are particularly suited to wet climates, and for locations where the temperature drops below freezing. Drain 1218 is a pipe 1220 with one or more drain holes 1222 penetrated through its walls. The length of drain 1218 depends on design parameters, but drain 1218 should extend from underlying surface 2224 beyond the expected height of growth medium 2226 (shown in Figure 23). Pipe 1220 can be made of any suitable material including, but not limited to, rubbers, plastics and metals.

[0091] In another embodiment (not shown) pipe 1220 is a shaped porous mesh. The mesh can be made of any suitable material including, but not limited to, rubbers, plastics and metals.

[0092] Reference is now made to Figures 14 and 15, which illustrate cross-sectional views of interlocking water retention compartments 1412A and 1412B, of panels 1400A and 1400B, respectively. Water retention

compartments 1412A, 1412B are similar to water retention compartments 112, and panels 1400 are similar to panels 100, and corresponding components are identified with similar reference numerals. In some embodiments, water retention compartments 1412A, 1412B are formed such that the outer surface has a first interlocking member 1428 and the inner surface has a second interlocking member 1430. Water retention compartments 1412A, 1412B are interlocked by pressing first interlocking member 1428 of one water retention compartment 1412A into second interlocking member 1430 of another water retention compartment 1412B. Interlocked water retention compartments 1412A, 1412B can be pulled apart. In some embodiments water retention compartments 1412A, 1412B can be interlocked by an interference fit.

[0093] Reference is now made to Figures 16 and 17. Figure 16 is a perspective view of water retention compartment 1612. Figure 17 illustrates a side view of another embodiment of water retention compartment 1712. Water retention compartments 1612 and 1712 are similar to water retention compartments 112, and corresponding components are identified with similar reference numerals.

[0094] Water retention compartments 112 can be any practical size or shape. The volume of a water retention compartment 112 may range from 5 ml to 250 ml.

[0095] Reference is now made to Figures 18 and 19, which show cross-sectional views of an embodiment of nesting water retention compartments 1812A and 1812B, of two separate panels 1800A and 1800B, respectively. Water retention compartments 1812A, 1812B are similar to water retention compartments 112, and panels 1800A, 1800B are similar to panels 100, and corresponding components are identified with similar reference numerals. Water retention compartments 1812A, 1812B are formed such that the outer surface of a water retention compartment 1812A is receivable by another water retention compartment 1812B, as shown In this way panels 1800A and 1800B can be connected to each other by overlapping panel 1800B with panel 1800A such that a row of water retention compartments 1812A in panel 1800A nest in a corresponding row of water

retention compartments 1812B in panel 1800B. Optionally, panels 1800A and 1800B may be affixed to each other by fasteners 1832, as shown in Figures 18 and 19. Suitable fasteners include rivets, staples, stitching, clips, screws, nuts and bolts, and combinations thereof, for example. Chemical bonds, heat bonds, and other adhesives such as plastic welding may also be used to affix separate panels 1800A and 1800B to each other.

[0096] Reference is now made to Figure 20. Figure 20 illustrates a top view of another embodiment of carrier 2008. Carrier 2008 is similar to carrier 108, and corresponding components are identified with similar reference numerals. In this embodiment one or more water retention compartments 2012A are of lesser volume than remaining water retention compartments 2012B such that interlocking first interlocking members 2028 (not shown) with second interlocking members 2030 (not shown) is facilitated.

[0097] Reference is now made to Figure 21. Figure 21 illustrates a cross-sectional view of another embodiment of panel 100, shown at 2100. Panel 2100 is similar to panel 100, and corresponding components are identified with similar reference numerals. A filter 2134 is disposed between a carrier 2108 and an anchor layer 2106.

[0098] In this embodiment, anchor layer 2106 and filter 2134 can be affixed to each other and to carrier 2108 by any suitable means including, but not limited to, chemical bonds, heat bonds, and mechanical fasteners such as rivets or stitching, and by plastic welding. Anchor layer 2106 and filter 2134 are positioned on carrier 2108 such that one or more water retention compartments 2112 are left uncovered by anchor layer 2106 and filter 2134.

[0099] Filter 2134 may be of any suitable water permeable material that impedes the passage of growth medium 2226 (Figure 23), such materials include, but are not limited to, polyester, cotton, rock-wool, and combinations thereof. In some embodiments filter 2134 is a woven material. Filter 2134 may have any practical dimensions as design parameters permit. In one embodiment filter 2134 is between 0.01 mm and 80 mm thick.

[00100] Reference is now made to Figures 22 and 23. Figure 22 illustrates a top view of an embodiment of a green roofing system 2236

according to the present invention. In this embodiment, green roofing system 2236 is partially installed and covers an underlying surface 2224 surrounded by a curb 2238. Figure 23 illustrates a cross-sectional view of a portion of green roofing system 2236. Green roofing system 2236 includes panels 2200A and 2200B but more panels may be used, growth medium 2226, and vegetation 2240. Green roofing system 2236 may be used with all embodiments of green roofing panels 100.

[00101] Panels 2200A and 2200B are connected by interlocking, or nesting, water retention compartments 2212 as described above. Water retention compartments 2212 of panel 2200A are interlocked (or nested) with corresponding water retention compartments 2212 of panel 2200B. As many or as few water retention compartments 2212 may be interlocked (or nested) as are required to securely install green roofing system 2236.

[00102] Growth medium 2226 may be any medium suitable for growing vegetation 2240 including, but not limited to, soil, sand, clay, gravel, fertilizer, peat, compost, super-absorbent polymers, and combinations thereof.

[00103] Vegetation 2240 includes, but is not limited to, herbs, grasses, mosses, wild plants, wild flowers, other plants, and combinations thereof.

[00104] Green roofing system 2236 may be installed on any suitable surface including, but not limited to, flat roofs, pitched roofs, and vertical walls.

[00105] In some embodiments (not shown) green roofing system 2236 comprises bubble foil disposed between panel 2200 and underlying surface 2224. Bubble foil acts as an insulator and a vapor barrier. In some embodiments bubble foil is rFOIL marketed by TVM Building Products of Ontario, Canada.

[00106] Reference is now made to Figure 46. Figure 46 is a perspective view of another embodiment of green roofing system 2436 according to the present invention. The components of green roofing system 4636 are similar to those of system 2236, and corresponding components are identified with similar reference numerals. As shown, adjacent panels 4600A, 4600B are nested in a connective carrier 4608. This configuration is suitable for situations where it is preferable not to overlap panels 4600.

[00107] Reference is now made to Figure 24. Figure 24 is a perspective view of another embodiment of green roofing system 2436 according to the present invention. The components of green roofing system 2436 are similar to those of system 2236, and corresponding components are identified with similar reference numerals. As shown, green roofing system 2436 comprises multiple panels 2400 installed on an underlying surface 2424.

[00108] In the embodiment shown in Figure 24, a waterproof roofing membrane 2442 is shown intermediate green roofing panels 2400 and underlying surface 2424. In some applications, it is desirable to have a waterproof membrane 2442 positioned directly under green roofing panels 2400. Such membranes 2442 may also serve as a root barrier to prevent unwanted propagation of roots from vegetation 2440, especially in cases where drainage means 2416 are employed. Alternatively, a separate membrane (not shown) may be employed as a root barrier. In other embodiments, such as where a green roofing system is installed on a wooden deck, for example, the roofing membrane 2442 may be not be in direct contact with panels 2400. Drains 2418 are also shown in the embodiment shown in Figure 24.

[00109] As shown in Figure 24, green roofing system 2436 is bordered by an edge detail 2444. Edge detail 2444 serves to define the outer edge of green roofing system 2436 and supports green roofing system 2436 on underlying surface 2424. Edge detail 2444 may be made of aluminum, galvanized steel, plastic, wood or another suitable material.

[00110] An erosion control mesh 2445 is also shown in the embodiment of green roofing system 2436 illustrated in Figure 24. Erosion control mesh 2445 is placed over panels 2400, and is used to cover green roofing system 2436 as required to provide additional support to vegetation 2440 as it grows through openings 2447 of erosion control mesh 2445. Erosion control mesh 2445 can be made from a variety of plastics and metals and typically will have openings ranging from 1cm to 25cm. The erosion control mesh 2445 with openings 2447 outside of this range may also be used. The size of suitable openings 2447 depends on the types of vegetation 2440 grown. The dimensions of erosion control mesh 2445 are variable, but typically sheets

between 1mm and 10mm in thickness and 0.5m to 2m in width will be cut from a roll in lengths as needed.

[00111] Reference is now made to Figure 25. Figure 25 illustrates a cross-sectional view of an embodiment of green roofing system 2536 installed on an underlying surface 2524. The components of green roofing system 2536 are similar to those of system 2236, and corresponding components are identified with similar reference numerals. A panel 2500 is bent and affixed to a curb 2538 by fasteners 2546. Fasteners 2546 can be any suitable fasteners depending on the characteristics of curb 2538. For example, fasteners 2546 include nails, screws, concrete nails, lags, nuts, bolts, and combinations thereof. Roofing sealant (not shown) is disposed between panel 2500 and curb 2538. In another embodiment (not shown), green roofing system 2536 is affixed to underlying surface 2524 by fasteners 2546 and may or may not be affixed to curb 2538.

[00112] A perspective view of another embodiment of green roofing system 2236 according to the present invention is shown in Figure 26 at 2636. The components of green roofing system 2636 are similar to those of system 2236, and corresponding components are identified with similar reference numerals. Figure 26 shows an edge detail 2644 affixed to a paving stone 2648 by fasteners 2646 (not shown). Also, as shown, a flashing 2650 covers panels a 2600 and a curb 2638 and adds additional structural integrity to green roofing system 2636. Typically flashing 2650 will be made of aluminum, galvanized steel, or plastic, however, in other embodiments other materials may be used.

[00113] Also shown in Figure 26 is a substrate 2651 containing growth medium 2626. A cross sectional view of multiple substrate socks 2651 is shown in the embodiment of green roofing system 2636 illustrated in Figure 26B. Substrate sock 2651 can be made from a variety of porous synthetic and natural materials. For example substrate sock 2651 may be woven from a plastic such as polyester, or a natural material such as hemp. Typically, substrate sock 2651 will have a generally tubular shape ranging with a diameter of 2cm or more. In one embodiment, substrate socks with a diameter ranging from 10cm to 60cm is used. A substrate sock may

dimensions outside of these ranges. The length of substrate sock 2651 will vary depending on the required application, but will typically be 50cm or longer. For example, an embodiment may have a plurality of substrate socks ranging from 0.5m to 25m in length. In other embodiments, a substrate sock may have a length outside these ranges. Substrate sock 2651 can serve a variety of functions. For example, substrate sock 2651 can be used to weigh down green roofing panels 2600 in order to mitigate against uplift forces on panels 2600 created by wind. For this purpose, substrate sock 2651 will typically be positioned around the outer edges of green roofing system 2636 closest to the edge of underlying surface 2624. Substrate sock 2651 also serves another means in which for vegetation 2640 to grow. By virtue of the porous structure of substrate sock 2651, vegetation 2640 is able to grow in growth medium 2626 in substrate sock 2651 and at least partially cover substrate sock 2651. Substrate sock 2651 can also serve to create landscaping effects.

[00114] Reference is now made to Figures 27 and 28. Figure 27 is a cross-sectional view of an embodiment of an edge detail 2744. Figure 28 illustrates a cross-sectional view of another embodiment of a green roofing system 2736 interlocked with edge detail 2744 installed on an underlying surface 2724. The components of green roofing system 2736 are similar to those of system 2236, and corresponding components are identified with similar reference numerals. Edge detail 2744 has interlocking means 2754 corresponding with a first interlocking member 1428 and a second interlocking member 1430 of panels 1400 such that edge detail 2744 and panels 1400 can be interlocked. Edge detail 2744 surrounds outer edge of green roofing system 2736. Edge detail 2744 can be made of any suitable material including, but not limited to, rubber and plastics such as polyester, polyethylene, polyvinyl chloride, polypropylene, and metals such as aluminum and galvanized steel, and combinations thereof.

[00115] Ballast 2756 placed in ballast zone 2758 affixes green roofing system 2736 to underlying surface 2724. Ballast 2756 includes, but is not limited to, gravel, cinder blocks, brick, crushed stone, sand, river-rock, and combinations thereof. In some embodiments, edge detail 2744 is affixed to

underlying surface 2724 by fasteners 2746 (not shown). In some other embodiments ballast 2756 is placed at various locations on green roofing system 2736.

[00116] Reference is now made to Figure 29, which shows a top view of an embodiment of nested panels 2900. Panels 2900 are similar to panels 100, and corresponding components are identified with similar reference numerals. As shown, panels 2900 have been cut to so as to accommodate an angled joint 2960. Panels 2900 may be cut to almost any shape so as to accommodate a particular geometry of an underlying surface 2924. For example, panels 2900 could be cut so as to fit around chimneys or air ducts located on underlying surface 2924. As shown in Figure 29, panels 2900 along angled joint 2960 do not overlap each other. Instead, an edge detail 2944A and 2944B (shown in heavy broken lines) are disposed under panels 2900 (as described above) and abut to form angled joint 2960, as shown. While an angled joint 2960 is shown in Figure 29, it will be obvious to one skilled in the art that similar panels 2900 can be made to accommodate almost any geometry.

[00117] Reference is made to Figure 30, which shows a cross-sectional view of another embodiment of green roofing system 2236 at 3036 according to the present invention. The components of green roofing system 3036 are similar to those of system 2236, and corresponding components are identified with similar reference numerals. In this embodiment growth medium 3026 is disposed in water retention compartments 3012, as shown. Growth medium 3026 may serve several purposes. If less water retention capacity is desirable, for example, gravel may be used to partially fill the volume of water retention compartments 3012. In other applications, growth medium may be chosen based on the nutrient requirements of vegetation.

[00118] A cross-sectional view of another embodiment of green roofing system 2236 according to the present invention is shown at 3136 in Figure 31. The components of green roofing system 3136 are similar to those of system 2236, and corresponding components are identified with similar reference numerals. In this embodiment an edge detail 3144 is affixed to an underlying

surface 3124 by fastener 3146, and a panel 3100 abuts edge detail 3144 and fastener 3146.

[00119] A cross-sectional view of another embodiment of green roofing system 2236 according to the present invention is shown at 3236 in Figure 32. The components of green roofing system 3236 are similar to those of system 2236, and corresponding components are identified with similar reference numerals. In this embodiment, a paving stone 3262 is disposed on a panel 3200 adjacent a divider plate 3264. Divider plate 3264 is affixed to a carrier 3208 by a fastener 3232 as shown. Typically divider plate 3264 will be made of aluminum, galvanized steel, or plastic, however, in other embodiments other materials may be used.

[00120] A cross-sectional view of another embodiment of green roofing system 2236 according to the present invention is shown at 3336 in Figure 33. The components of green roofing system 3336 are similar to those of system 2236, and corresponding components are identified with similar reference numerals. In this embodiment anchor layers 3306 are disposed on opposite sides of a divider plate 3364, and divider plate 3364 is affixed to a carrier 3308 by a fastener 3332 as shown. Additionally, growth medium 3326 is disposed on an anchor layer 3306 to provide additional support for vegetation 3340.

[00121] A cross-sectional view of another embodiment of green roofing system 2236 according to the present invention is shown at 3436 in Figure 34. The components of green roofing system 3436 are similar to those of system 2236, and corresponding components are identified with similar reference numerals. In this embodiment, growth medium 3426 is disposed to form a hill 3466 on an anchor layer 3406 with vegetation 3440. Additionally, a roofing membrane 3442 is disposed intermediate a panel 3400 and an underlying surface 3424.

[00122] A cross-sectional view of another embodiment of green roofing system 2236 according to the present invention is shown at 3536 in Figure 35. The components of green roofing system 3436 are similar to those of system 2236, and corresponding components are identified with similar reference

numerals. In this embodiment, an erosion control mesh 3545 is shown with with vegetation 3440 growing through openings 3547.

[00123] A cross-sectional view of another embodiment of green roofing system 2236 according to the present invention is shown at 3636 in Figure 36. The components of green roofing system 3636 are similar to those of system 2236, and corresponding components are identified with similar reference numerals. In this embodiment, a panel 3600 is secured to an anchor plate 3672 by a fastener 3646A and anchor plate 3672 is secured to an underlying surface 3624 by fasteners 3646B, as shown. A membrane 3642 is disposed intermediate underlying surface 3624 and a carrier 3608. Fastener 3646A passes through membrane 3642, and fasteners 3646B remain under membrane 3642.

[00124] Reference is now made to Figures 40, 41, and 42. Figure 40 illustrates a top view of green roofing system 4036 and irrigation means 4094. Figure 41 illustrates a cross-sectional view of green roofing system 4036 and irrigation means 4094. Figure 42 illustrates a side view of irrigation means 4094. Irrigation means 4094 include irrigation pipes 4096 and brackets 4098. Irrigation means 4094 may be used with all embodiments of green roofing system 4036.

[00125] Brackets 4098 are interlocked with panels 4900 and irrigation pipe 4096 is fastened to brackets 4098.

[00126] Irrigation pipe 4096 can be made of any suitable material including, but not limited to, rubbers, plastics and metals. Irrigation pipe 4096 has water outlets 40100. Irrigation pipe 4096 can be in any size or shape as design parameters permit.

[00127] In one embodiment irrigation pipe 4096 is cylindrical having a diameter between 0.5 cm and 20 cm. In another embodiment irrigation pipe 4096 is a commercially available soaker hose, which allows water to seep out through its outer walls.

[00128] Bracket 4098 includes a base 40102 and a clamp 40104. Base 40102 can be made of any suitable material including, but not limited to,

rubber and plastics such as polyester, polyethylene, polyvinyl chloride, polypropylene, and combinations thereof.

[00129] Base 40102 is interlocked with panel 4000. Base 40102 has interlocking member 40106. Base 40102 can be interlocked with panel 4000 by pressing interlocking member 40106 into second interlocking member 4030 of water retention compartment 4012. Interlocked base 40102 can be pulled out of water retention compartment 4012. In some embodiments base 40102 and panel 4000 can be interlocked by an interference fit.

[00130] Clamp 40104 can be any suitable mechanical fastening means. In some embodiments clamp 40104 is a cable zip-tie. In another embodiment clamp 40104 is a hose clamp.

[00131] Reference is now made to Figure 43. Figure 43 illustrates a top view of green roofing system 4336 and of another embodiment of irrigation means 4336. Irrigation means 4336 comprise sprinklers 43108. Sprinklers 43108 may be any suitable type including, but not limited to, spray head, rotor head, oscillating, pop-up, and combinations thereof. Irrigation pipes 4396 in this embodiment may or may not have water outlets 40100.

[00132] A perspective view of another embodiment of green roofing system 2236 according to the present invention is shown at 3936 in Figure 39. The components of green roofing system 3936 are similar to those of system 2236, and corresponding components are identified with similar reference numerals. In this embodiment, green roofing system 3936 is installed on a pitched underlying surface 3924. Panels 3900 overlap and are affixed to underlying surface 3924 by fasteners 3946. In the embodiment shown, panels 3900 overlap in a shingled fashion such that the panels 3900 are generally installed moving up the pitch of underlying surface 3924, i.e. so that upper panels 3900A overlap adjacent lower panels 3900B Installing roofing panels 3900 in this manner allows for panels 3900 to replace roofing shingles that would normally be installed on a pitched roof. Green roofing system 3936 is also supported by edge detail 3944, which is affixed to underlying surface 3924 by fasteners 3946 (not shown).

[00133] Additionally a peak attachment adapter 3962 is disposed intermediate carrier 3908 and anchor layer 3906 of panels 3900 abutting at the peak of underlying surfaces 3924A. 3924B, as shown. Peak attachment adapter 3962 is also shown in Figures 39B and 44. Figure 39B is a perspective view an embodiment of green roofing system 3936 shown in Figure 39, and corresponding components are identified with similar reference numerals, but also includes a side brace 3970. Figure 44 is perspective view of peak attachment adapter 3962. Peak attach adapter 3962 has top flaps 39118A, 39188B which cover and are attached to a portion of carriers 3908A, 3908B, and is affixed to carriers 3908 by fasteners 3932 (not shown). Peak attachment adapter 3962 also includes bottom flaps 39120A, 39120B, which attach to underlying surfaces 3924A, 3924B with fasteners 3946. As shown, carrier 3908 is received in a cavity defined between top flap 39118 and bottom flap 39120. Peak attachment adapter 3962 further comprises a centre portion 39122 and flex grooves 39124, which facilitate bending of peak attachment adapter 3962 to accommodate the attachment angel between underlying surfaces 3924A, 3924B. Typically attachment adapter 3962 will be made of aluminum, galvanized steel, or plastic, however, in other embodiments other materials may be used.

[00134] Reference is now made to Figure 39C, which is a cross-sectional view showing side brace 3970 illustrated in Figure 39B. As shown, side brace 3970 is used to affix panel 3900 to underlying surface 3924. As shown, side brace 3970 is affixed to underlying surface 3924 by fasteners 3946, and is disposed intermediate anchor layer 3906 and carrier 3908. Side brace 3970 is affixed to carrier 3908 by bond 3971, as shown. Bond 3971 may be a chemical bond, a heat bond, or plastic weld, for example. Typically, side brace 3970 will be made of aluminum, galvanized steel, or plastic, however, in other embodiments other materials may be used.

[00135] A cross-sectional view of another embodiment of green roofing system 2236 according to the present invention is shown at 3736 in Figure 37. The components of green roofing system 3736 are similar to those of system 2236, and corresponding components are identified with similar reference numerals. In this embodiment, system 3736 is shown mounted to an inclined

underlying surface 3724 in proximity to a gutter 3774. An anchor 3706 is supported by an end plate 3776, which is attached to a carrier 3708 by fastener 3732, and carrier 3708 is affixed to an under plate 3778 by fastener 3746A. As shown, under plate 3778 is affixed to underlying surface 3724 by fasteners 3746B and 3746C.

[00136] Reference is now made to Figure 38. Figure 38 illustrates a cross-sectional view of another embodiment of green roofing system 3836 installed on an underlying surface 3824 with tension system 3880. The components of green roofing system 3836 are similar to those of system 2236, and corresponding components are identified with similar reference numerals. Tension systems 3880 are installed around the outer edge of green roofing system 3836 as required to secure installation. Tension system 3880 includes an edge detail 3844 comprising a bracing means 3882 attached to a tightening bracket 3884. Tightening bracket 3884 is attached to a mechanical fastener 3886 affixed to a face 3888 of underlying surface 3824. Tightening bracket 3884 comprises male threaded rods 3890 and a female linkage 3892. By turning female linkage 3892, tension is applied to green roofing system 3836 as required to secure installation. Male threaded rods 3890 and female linkage 3892 can be made of any suitable material including, but not limited to, metal and plastics.

[00137] A perspective view of another embodiment of green roofing system 2236 according to the present invention is shown at 4536 in Figure 45. The components of green roofing system 4536 are similar to those of system 2236, and corresponding components are identified with similar reference numerals. In this embodiment, green roofing system 4536 is installed on a pitched underlying surface 4524 abutting a parapet 45128. As shown, in this embodiment a peak attachment adapter 4562 is attached to a carrier 4508 and an underlying surface 4524 by fasteners 4546. In this embodiment, peak attachment adapter 4562 comprises a top flap 45118A attached to carrier 4508 and a top flap 45118B attached to underlying surface 4524, a centre portion 45122 is also attached to parapet 45128 by fasteners 4546.

[00138] Reference is now made to Figures 47 to 49. Figure 47 is a perspective view a green roofing panel 4700, according to an additional

embodiment of the present invention. Figure 48 is a cross sectional view of a portion of green roofing panel 4700. Figure 49 is a cross sectional view of a portion of green roofing panel 4700 with vegetation growing therefrom. Panel 4700 is similar to panel 600 and corresponding components are identified with similar reference numerals, incremented by 4100. Panel 4700 includes an anchor 4706 and a carrier 4708.

[00139] Carrier 4708 includes a web 4710 and a plurality of water retention compartments 4712 extending downward from a top portion of the web 4710. The water retention compartments 4712 can be provided in a regular repeating side-by-side pattern throughout web 4710. Alternatively, water retention compartments 4712 may follow a repeating, staggered pattern, for example, as defined by the water retention compartments 1012 shown in Figure 10.

[00140] Anchor 4706 (also called a bio blanket) is generally similar to anchor 606 except that anchor 4706 has dimples 4720. Anchor 4706 lies against the top portion (i.e. upper surface) of carrier 4706 in a generally continuous fashion.

[00141] As shown in Figure 47 (with a portion of anchor 4706 peeled away from carrier 4708), the anchor includes a mat portion that is generally flat, and a plurality of dimples 4720 each presenting a protruding portion 4721 that extends from the underside of the mat of the anchor 4706 to a base portion of the dimple 4720. The protruding portions 4721 are adapted to nest inside water retention compartments 4712, which nesting can interlock anchor 4706 and carrier 4708 together.

[00142] The dimples 4720 are positioned on anchor 4706 to correspond to positions of the water retention compartments 4712 in the web 4710. The positioning of the dimples on the anchor 4706 can follow a repeating side-by-side or staggered pattern similar to that of water retention compartments 4712. Protruding portions 4721 can have an external geometry shaped to match the interior shape of water retention compartments 4712 to provide a snug fit such that an exterior surface of the protruding portion 4721 contacts the interior surface of the water retention compartment 4712. Nesting anchor

4706 within carrier 4708 in this manner can reduce the need for alternative affixing means such as rivets, plastic weldings or other fasteners previously described. Depending on the application and degree of nesting, fasteners may or may not be used to secure anchor 4706 to carrier 4708. Alternatively, the bottom portion or anchor 4706 or the top portion of carrier 4708 may include an adhesive to secure anchor 4706 to carrier 4708. For example, a spray adhesive may be used.

[00143] Dimples 4720 can be generally circular in shape (when viewed from above), having a diameter D, and a depth L. In the example illustrated, the sidewalls (forming the protruding portions) and base of the dimples 4720 are of generally equal thickness in cross-section, and have the same cross-sectional thickness as the planar mat portion (i.e. portions intermediate adjacent dimples 4720) of anchor 4706. The diameter D can be between 1 cm and 25 cm, and the depth L can be between 0.1 cm and 10 cm. The particular dimensions of the diameter D and depth L can be increased or decreased depending on the overall size and thickness of panel 4700, or to suit a particular installation or types of vegetation to be supported by the panel 4700. The anchor 4706 can have a thickness of between 0.1 cm and 20 cm.

[00144] Protruding portions 4721 can be tapered either inward or outward with increasing distance from the underside of the mat of anchor 4706. In the example illustrated, protruding portions 4721 are tapered inward from the underside of anchor 4706, decreasing in diameter with increasing distance from the mat. This inward tapering of the dimples 4720 can provide easier installation of anchor 4706 into carrier 4708. The inward tapering can also facilitate manufacturing of the anchor 4706, as with a punch for forming the dimples. Alternatively, protruding portion may be tapered outward from the underside of anchor 4706, increasing in diameter with increasing distance from the underside of the mat of the anchor 4706. Such outward tapering can provide a snap-fit interlocking action of the dimples within the water retention compartments, which can increase the retention force provided by the interlocking. In embodiments where protruding portion 4721 has an outward taper, water retention compartment 4712 may also have an outward taper.

[00145] In some embodiments, protruding portions 4721 may be cylindrical, frustoconical, hemi-spherical, rectangular or other shapes, and the interior shape of water retention compartments 4712 can match that of the protruding portions 4721 of the dimples. The bottom edges of protruding portions 4721 can be filleted to allow easier alignment of anchor 4706 with respect to carrier 4708.

[00146] Anchor 4706 (and the mat portion thereof) can be made from a porous sheet of intertwined fibers, such as: hemp, rockwool, wood fibers, coconut fibers, plastics (such as polyester, polyethylene, polyvinyl chloride, polypropylene) regular/irregular intertwined wire, coated wire, metals (such as copper and steel), combinations of the preceding and other materials. The intertwined fibers of anchor 4706 can provide a platform or support mat for growth of vegetation 4740. Anchor 4706 may include a growth media to provide nutrients to vegetation 4740. For example, growth media may include soil, sand, gravel, fertilizer, peat, compost, super-absorbent polymers and combinations thereof.

[00147] As shown in Figure 49, roots 4742 of vegetation 4740 can entangle within anchor 4706. Accordingly, dimples 4720 can allow roots 4742 to grow to the bottom of water retention compartments 4712, providing better access to water and nutrients located therein. The dimples 4720 may also provide a repository for a growth medium, water, vegetation nutrients and other materials.

[00148] As shown in Figure 49, dimples 4720 can include tapered walls 4724 of lower fiber density to promote growth and entanglement of roots 4742. The walls 4724 can promote water and nutrient transfer from water retention compartments 4712 to vegetation 4740 growing in the underside of anchor layer 4706. In additional embodiments, anchor 4706 may include other portions having lower fiber density to achieve similar benefits to those described above.

[00149] At least the distal end of the protruding portion of the dimples 4720 can contact liquids contained in the retention compartments 4712. The dimples can thus absorb and redistribute water through capillary action to

other portions of anchor 4706, which can improve nutrient transfer and promote healthier plant growth.

[00150] The upper surface of the anchor can be flat, providing an anchor that is thicker through the dimple sections than through non-dimpled sections. In other words, the dimples can in some examples (not illustrated) comprise protruding portions extending from the underside of the anchor, without any corresponding recesses in the upper surface of the anchor. Such a configuration can provide increased water and/or growth media retention capability, particularly in the portions proximate the water retaining compartments of the carrier.

[00151] Alternatively, as in the example illustrated, the upper surface of the anchor 4706 can have recesses or pockets generally corresponding to the inner (upwardly facing) surface of the protruding portions 4721 of the dimples 4720. Anchors with a flat upper surface (not shown) can be vulnerable to movement or shifting of the growth media (e.g. by wind and water), which can adversely affect growth characteristics for vegetation supported by the anchor. In the example illustrated, the recessed pockets of the dimples 4720 can reduce such erosion effects by providing a seat for the growth media that is sheltered below the upper surface of the anchor, and disposed generally within water retention compartments 4712. In the example illustrated, since growth media is provided below the top surface of anchor 4706 (i.e. within the recesses of the dimples 4720), wind and water are inhibited from eroding the growth material away from the recesses. The dimples 4720 thus provide recesses or pockets internal of the dimples in which vegetation can take root. The roots 4742 can extend to (and be anchored in) the base of the dimples 4720, at a point below the upper surface of the carrier web. Thus wind and rainfall are less likely to move or damage vegetation 4740, and the panel 4700 can provide a more stable environment for vegetation in comparison to conventional flat anchors.

[00152] Referring again to Figure 48, carrier 4708 can further include drainage holes 4722. Drainage holes 4722 can drain away excess water from roofing panel 4700, which can, for example, enhance aeration. The size, location and number of drainage holes 4722 can be determined by design

parameters such as climate, vegetation hydration requirements and other drainage requirements for the green roofing system as previously described.

[00153] Sediment accumulation around drainage holes is a notable problem with conventional panels that include a filtration layer between the carrier and anchor. As water filters through the filtration layer, sediment collects and a sediment barrier can block the drainage holes. Slow accumulation can lead to decreasing drainage performance and eventually, complete blockage.

[00154] In the present embodiment, water tends to collect within a sump of the dimples 4720 and then settles in water retention compartments 4712. Since the sump of dimples 4720 lies below or to the side of drainage holes 4722, sediment is less likely to collect near drainage holes 4722. Collection of sediment near the sump of dimples 4720 can reduce the amount of sediment blockage around drainage holes 4722 to maintain better drainage performance with respect to sediment accumulation.

[00155] Referring now to Figures 50 and 51, illustrated therein is a perspective view of a stamping tool 5000 according to an embodiment of the present invention. The stamping tool can be used to make anchor layer 4706. Figure 50 is a perspective view of stamping tool 5000 and an anchor layer 4706 having dimples 4720. Figure 51 is a cross-sectional view of a portion of stamping tool 5000. Although stamping tool 5000 is described with reference to forming panel 4700, it will be understood by one skilled in the art that stamping tool 5000 may form other types of panels.

[00156] Stamping tool 5000 includes a top plate 5010 having a plurality of male heads 5012, and a bottom plate 5020 having a plurality of female wells 5022. The male heads 5012 are generally positioned to be receivable within the female wells 5022 when the top plate 5010 and the bottom plate 5020 are brought together. Both male heads 5012 and female wells 5022 can be positioned in a repeating side-by-side pattern corresponding to that of dimples 4720. Male heads 5012 can be slightly smaller than female wells 5022 to provide a clearance for the anchor layer and the formation of walls thereof. Top plate 5010 and bottom plate 5020 may be moved relative to each

other by a variety of means including manually in a press (i.e. by hand), or in a machine powered press, such as by pneumatic, hydraulic, or electrical power.

[00157] To form dimples 4720, a blank anchor layer (having no dimples) is placed on bottom plate 5020 and underneath the top plate 5010. Once the blank anchor layer is in position, top plate depresses, moving male heads 5012 toward the openings of female wells 5022. When male heads 5012 contact the blank and continue to be urged further into the blank mat, dimples 4720 begin to form on the blank anchor layer. Once stamping tool 5000 reaches the end of its stroke, top plate 5010 and bottom plate 5020 pull apart. Stamping tool 5000 should have a stroke that ends when top plate 5010 is separated from bottom plate 5020 by a distance approximately equal to the thickness of the blank anchor layer. Alternatively, stamping tool may have a slightly longer stroke that compresses the anchor layer. After stamping tool 5000 completely retracts, anchor layer 4706 can be removed and attached to carrier 4708.

[00158] As shown in Figures 50 and 51, male heads 5012 and female wells 5022 are generally cylindrical, but stamping machine 5000 can form tapered walls 4742 as described previously with reference to Figure 49. The tapered walls form after stamping tool retracts, and when the anchor layer retracts elastically to form the tapered walls 4742 around dimples 4720. The tool 5000 can include radially extendable/retractable sidewalls on the heads 5012 (such as an expanding collet or mandrel element) for forming reverse tapers. In alternative embodiments, male heads and female wells may be different shapes to provide alternative shapes. For example, male heads and female wells may be frustoconical, spherical, rectangular, or pyramidal.

[00159] As shown in Figure 51, female wells 5022 extend through bottom plate 5020. In alternative embodiments, female wells 5022 may extend only partially into bottom plate 5020.

[00160] In an additional embodiment of the present invention, anchor layer 4706 may be formed directly onto carrier 4708. In this embodiment, carrier 4708 is placed on bottom plate 5020 such that the underside of water

retention compartments 4712 nest inside female wells 5020. An adhesive may be applied to the top portion of carrier 4708 to promote secure attachment of the anchor layer to carrier 4708. Adhesive may also be applied to the underside of the blank anchor layer. The blank anchor layer (with generally flat upper and underside surfaces) is then positioned on top of carrier 4708 and top plate 5010 depresses onto bottom plate 5020. The top plate can comprise a peripheral element and a central element independent of the peripheral element, and can be pressed in a two stage operation, in which first the peripheral engagement element is lowered to grip the perimeter of the anchor layer, and second the central engagement element comprising the male heads 5012 is pressed towards the blank . As male heads 5012 contact the blank, dimples 4720 begin to form on the blank anchor layer. In addition, the blank anchor layer presses firmly against carrier 4708. If an adhesive is present, the adhesive bonds the blank anchor layer to carrier 4708. At the end of the stroke, top plate 5010 and bottom plate 5020 may be held in position to cure the adhesive. In some cases, top plate 5010 and bottom plate 5020 may squeeze together further during the curing step to improve contact between anchor layer 4706 and carrier 4708. Top plate 5010 and bottom plate 5020 then retract from each other and panel 4700 can be removed. The bonding of the anchor layer to the carrier and the forming of the dimples in the anchor layer can be formed in one operation (although the press may comprise first and second stages within the single operation).

[00161] Referring now to Figure 52, illustrated therein is a perspective view of a green roofing panel 5200, made in accordance with an additional embodiment of the present invention. Panel 5200 is similar to panel 600, and corresponding components are identified with similar reference numerals, incremented by 4600. Panel 5200 includes an anchor layer 5206 and a carrier 5208.

[00162] As shown, a growth medium 5226 is placed on anchor layer 5206. Vegetation clippings 5290 are then spread on growth medium 5226 to promote faster vegetation growth.

[00163] In an additional embodiment, a green roofing panel made according to one of the embodiments of the present invention may be placed

within a greenhouse or a similar facility to pre-grow vegetation. Pre-grown vegetation can allow faster and easier installation of panels. With pre-grown vegetation, benefits associated with green roofing systems can be realized almost immediately after installation.

[00164] As an example, a pre-grown panel can require less maintenance than conventional green roofs that are not pre-grown. When first installed, conventional green roofs may require significant maintenance with respect to watering, germination, and weeding. Careful maintenance can be required for up to two years for conventional green roofs, significantly raising the cost of the roofing panel. With a pre-grown panel, watering, germination and weeding can be carried out in a facility with a controlled environment and professional staff. Accordingly, healthier vegetation may grow on the pre-grown panels and less maintenance may be needed after installation.

[00165] Since the environment at a pre-grow site can be controlled throughout the seasons, pre-grown panels can be installed over a longer period without consideration for an initial growing period. In addition, vegetation on pre-grown panels can be heartier during the first months after installation. Accordingly, pre-grown vegetation can have better survivability during the first year after installation in comparison to the vegetation grown on conventional panels. Conventional panels without pre-grown vegetation can often experience growth difficulties after harsh seasonal weather conditions, for example, snowy or dry periods. A pre-grown panel may experience few difficulties in such harsh seasonal weather conditions and may have better survivability.

[00166] In an additional embodiment, vegetation may be pre-grown on a panel at a pre-grow site located geographically near an installation site. Pre-growing vegetation in the same, or a similar, climate to the installation site can improve the long-term survivability of the vegetation.

[00167] The invention has been described with regard to a number of embodiments. However, it will be understood by persons skilled in the art that other variations and modifications may be made without departing from the scope of the invention as defined in the claims appended hereto.

CLAIMS:

1. A roofing panel comprising:

a) a carrier comprising a web with an upper surface;

b) a plurality of water retention compartments provided in the web and depending generally downwardly from the upper surface of the web;

c) an anchor layer overlying at least a portion of the upper surface of the web, the anchor layer having an underside surface generally bearing against the upper surface of the web; and

d) a plurality of dimples provided on the anchor layer, each of the dimples comprising a protruding portion extending generally downwardly from the underside surface of the anchor layer, the protruding portions adapted to be received at least partially within respective ones of the water retention compartments.

2. The roofing panel of claim 1, wherein the dimples are positioned on the anchor to correspond to positions of the water retention compartments on the web, such that the protruding portions of at least a first group of the dimples nest inside a first group of the water retention compartments.

3. The roofing panel of claim 2, wherein the positions of the water retention compartments follow a repeating pattern.

4. The roofing panel of claim 1, wherein the protruding portions are shaped to correspond to an interior surface of the water retention compartments in which the protruding portions are nested.

5. The roofing panel of claim 4, wherein the protruding portions extend to a sufficient depth within the water retention compartments to generally abut a lower surface of the water retention compartments.

6. The roofing panel of claim 1, wherein each of the dimples comprises a base and a sidewall extending from the underside of the anchor layer to the base.

7. The roofing panel of claim 6, wherein the dimples are generally circular in shape when viewed from above, the dimples each having a diameter between 1 cm and 25 cm, and a depth between 0.1 cm and 10 cm.

8. The roofing panel of claim 6, wherein each dimple has an interior defining a recess in a top surface of the anchor, the top surface disposed opposite the underside surface.

9. The roofing panel of claim 8 wherein each recess in the dimples defines a sump, and wherein the carrier further comprises drainage holes, the drainage holes being located away from the sump.

10. The roofing panel of claim 6, wherein the anchor layer comprises intertwined fibers, and the sidewall of each of the dimples comprises a lower intertwined fiber density than other portions of the anchor layer.

11. The roofing panel of claim 10, wherein the anchor layer further comprises pre-grown vegetation, the pre-grown vegetation being grown at a site remote from the site of installation of the roofing panel.

12. A method of producing a roofing panel comprising the steps of:

a) placing a blank anchor layer in a stamping machine, wherein the stamping machine comprises: a first plate comprising a plurality of male heads, and a second plate comprising a plurality of female wells, the male heads and female wells being aligned such that the male heads are receivable within the female wells, the blank anchor layer being placed between the first plate and the second plate; and

b) forming a plurality of dimples in the blank anchor layer by closing the first plate and the second plate together such that the male heads align with the female wells.

13. The method of claim 12, further comprising the step of laying the blank anchor layer on an upper surface of a carrier, the carrier comprising a web, and a plurality of water retention compartments formed in the web, wherein a

first group of the dimples nest inside a first group of the water retention compartments.

14. The method of claim 12, wherein the step of forming the dimples includes pressing an underside of the blank anchor layer against the upper surface of the carrier.

15. The method of claim 12, further comprising the step of placing an adhesive on at least one of an underside surface of the blank anchor layer and the upper surface of the carrier.

16. The method of claim 12, further comprising the step of curing the adhesive.

17. A roofing system comprising a plurality of roofing panels, each of the plurality of roofing panels comprising:

a) a carrier comprising a web with an upper surface;

b) a plurality of water retention compartments provided in the web and depending generally downwardly from the upper surface;

c) an anchor layer overlying at least a portion of the upper surface of the web such that an underside of the anchor layer at least partially contacts the upper surface of the web; and

d) a plurality of dimples formed in the anchor layer, wherein each of the dimples comprises a protruding portion extending from an underside of the anchor layer, wherein at least one of the protruding portions nests inside at least one of the water retention compartments.

18. The roofing system of claim 17, wherein the plurality of roofing panels further comprises:

a) a first roofing panel with a first group of water retention compartments located laterally adjacent a first edge of the carrier of the first roofing panel;

b) a second roofing panel with a second group of water retention compartments located laterally adjacent a second edge of the carrier of the second roofing panel; and

wherein the first group of water retention compartments nests within the second group of water retention compartments.

19. The roofing system of claim 18, wherein a first group of the dimples on the anchor layer of either the first roofing panel, or the second roofing panel, nest inside the first group of water retention compartments.

20. The roofing system of claim 19, wherein the water retention compartments and the dimples have a repeating pattern to allow nesting of a first group of water retention compartments of a first roofing panel inside a second group of water retention compartments of a second roofing panel.

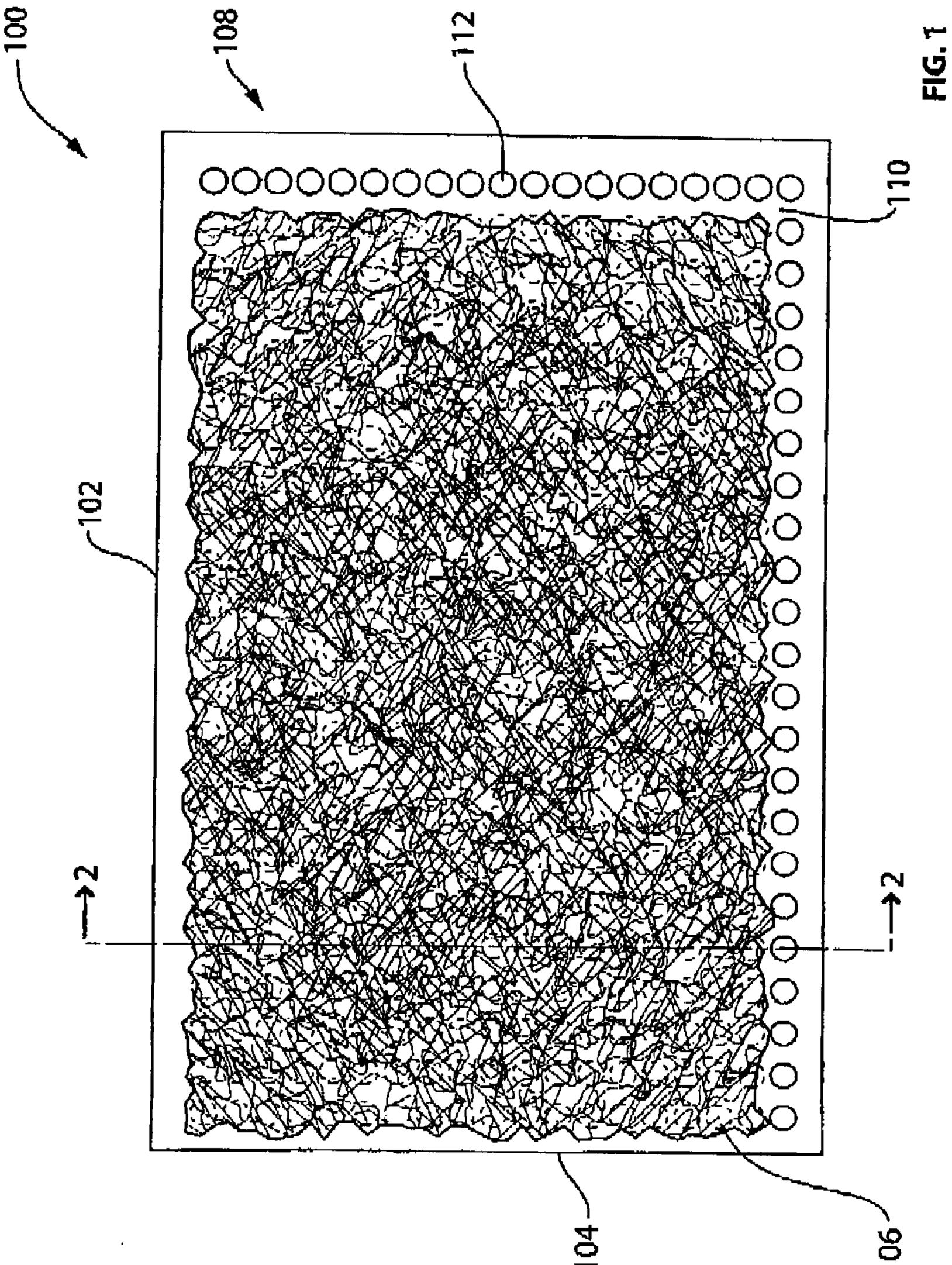


FIG. 1

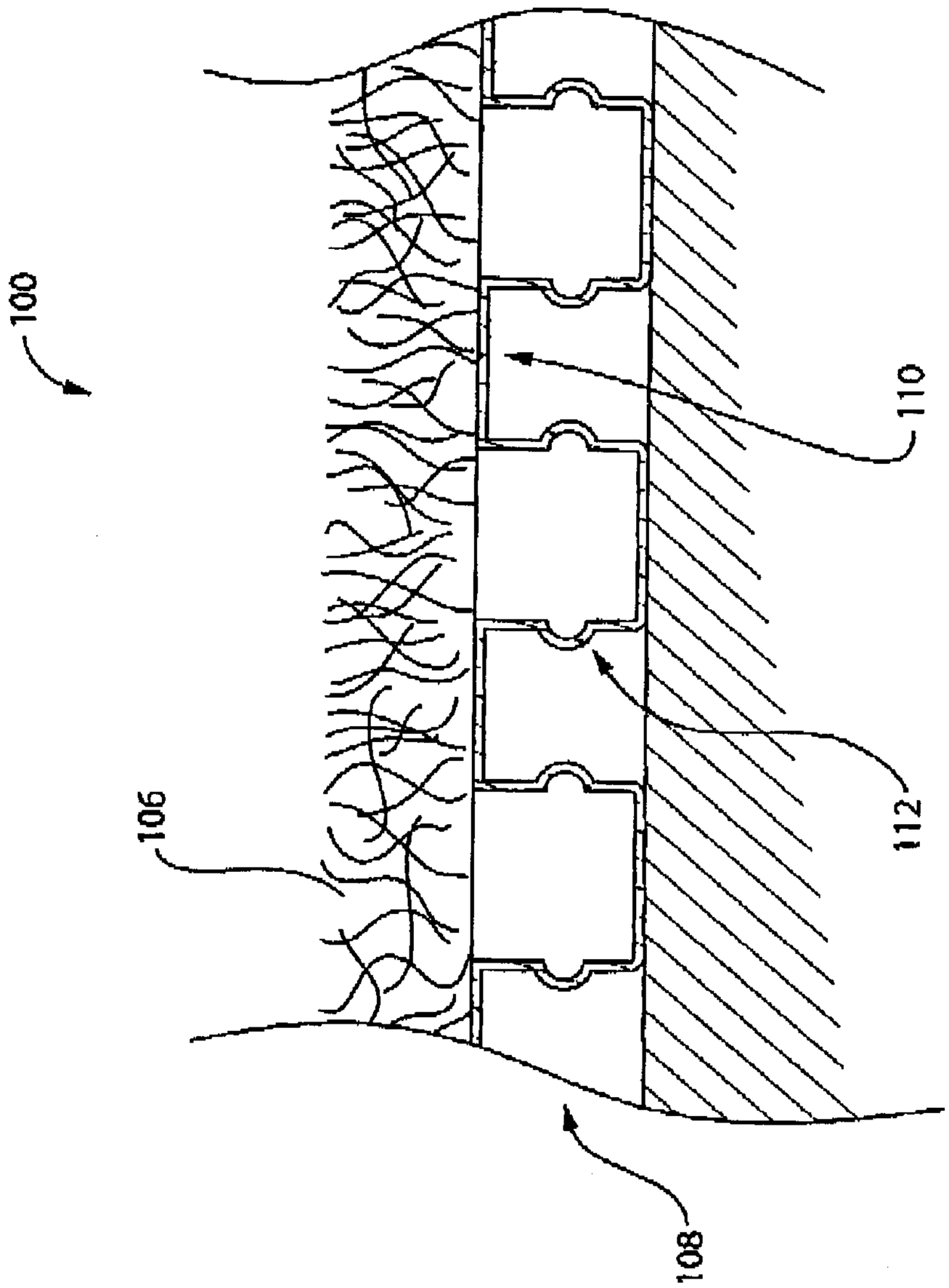


FIG. 2

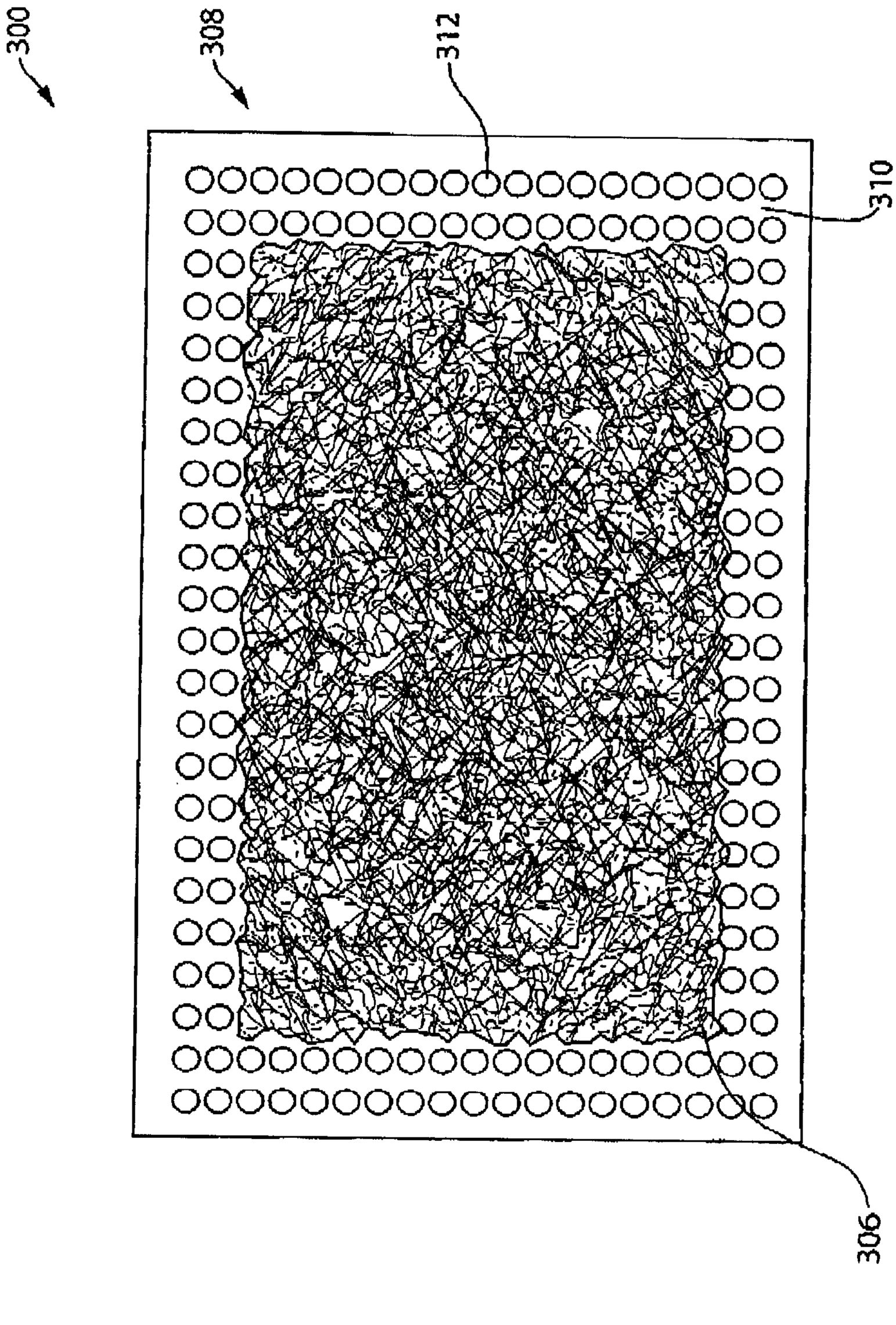


FIG.3

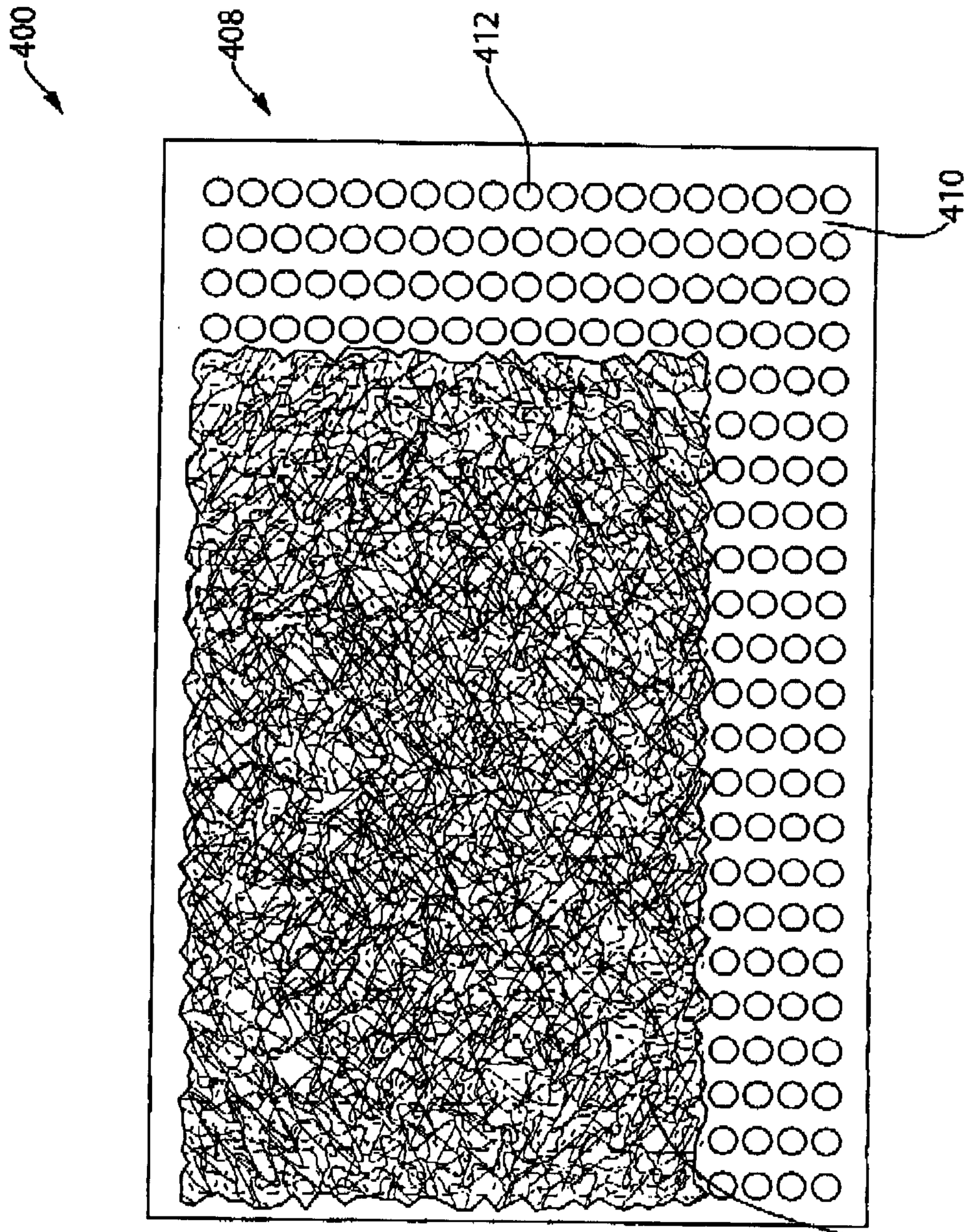


FIG.4

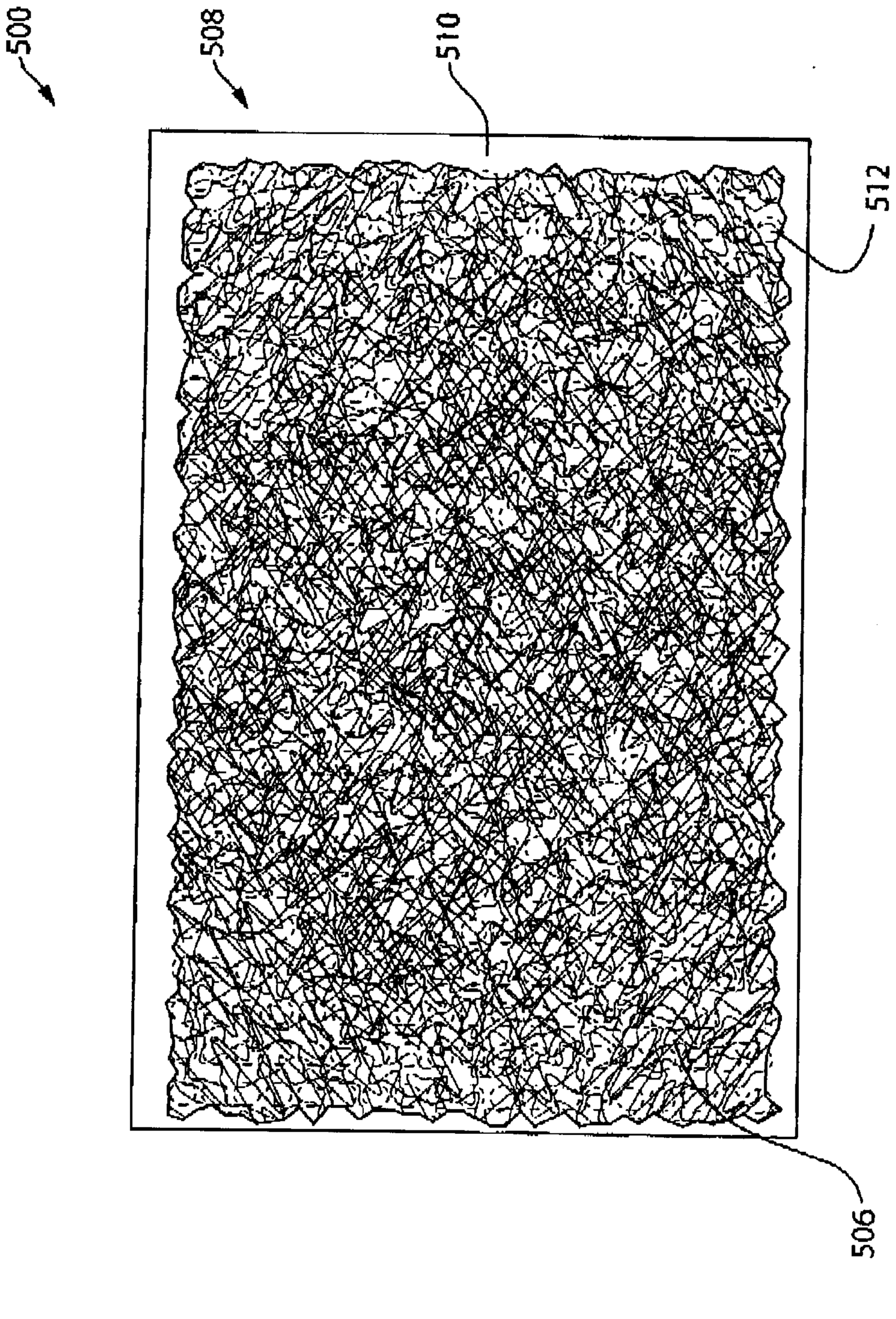


FIG. 5

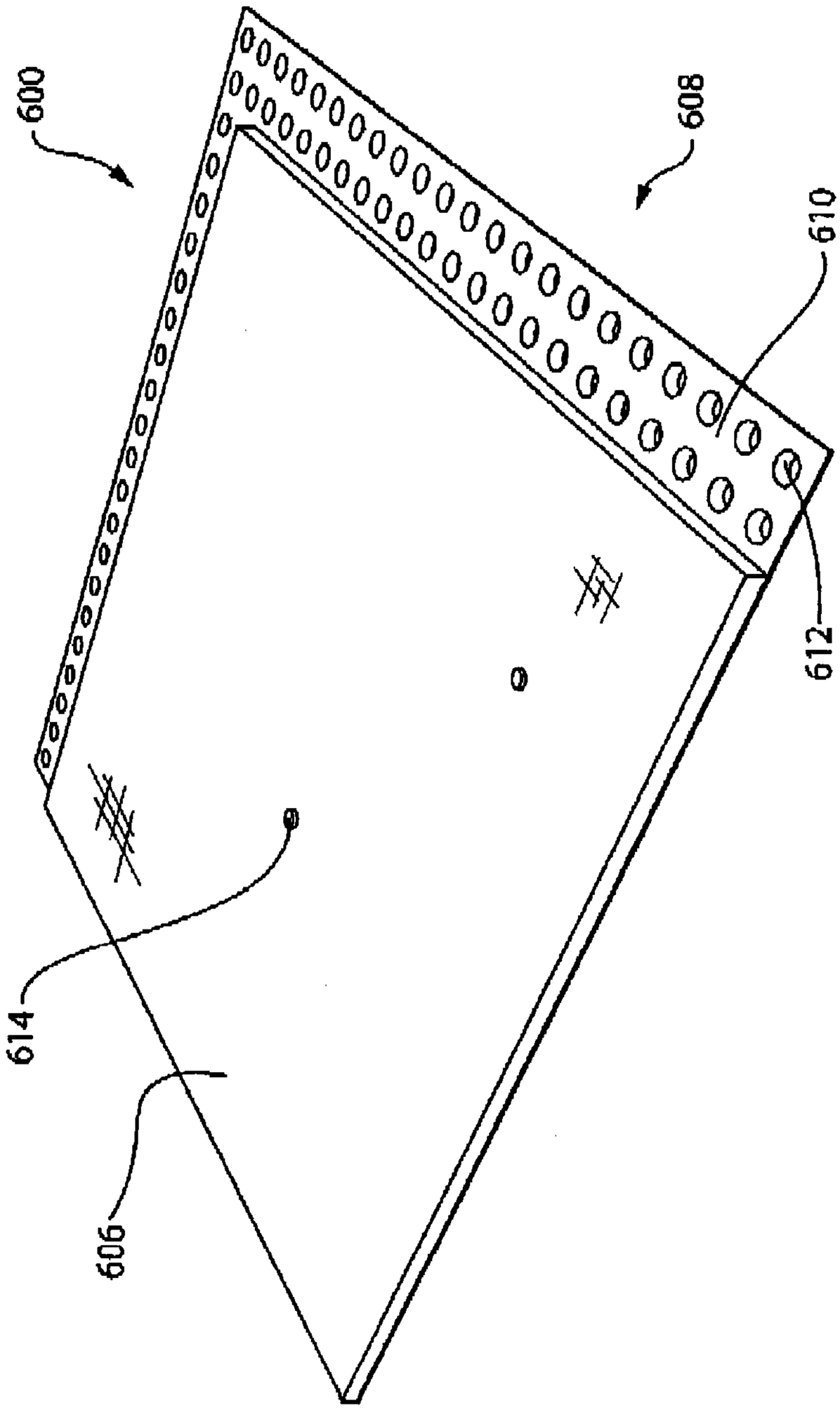


FIG.6

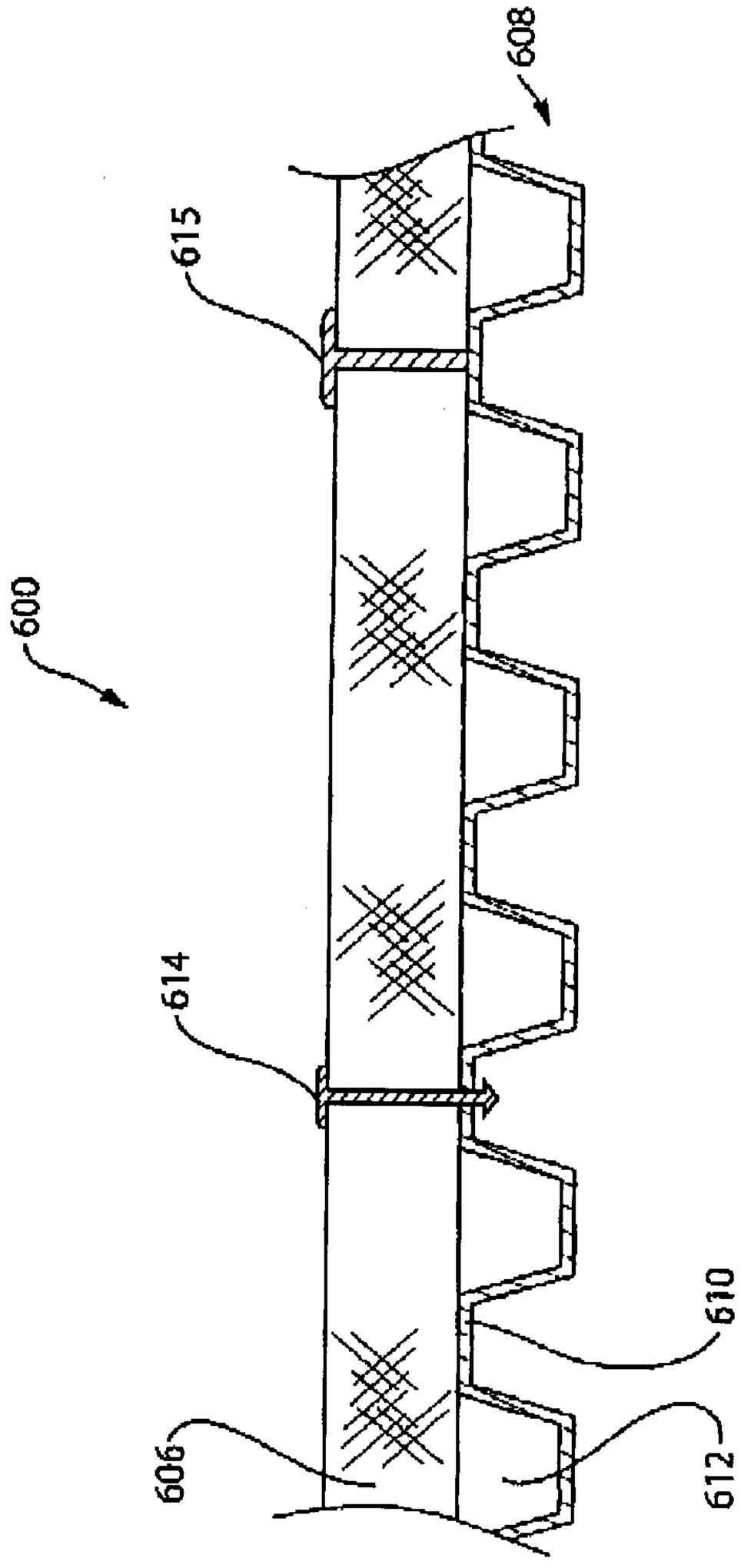


FIG. 7

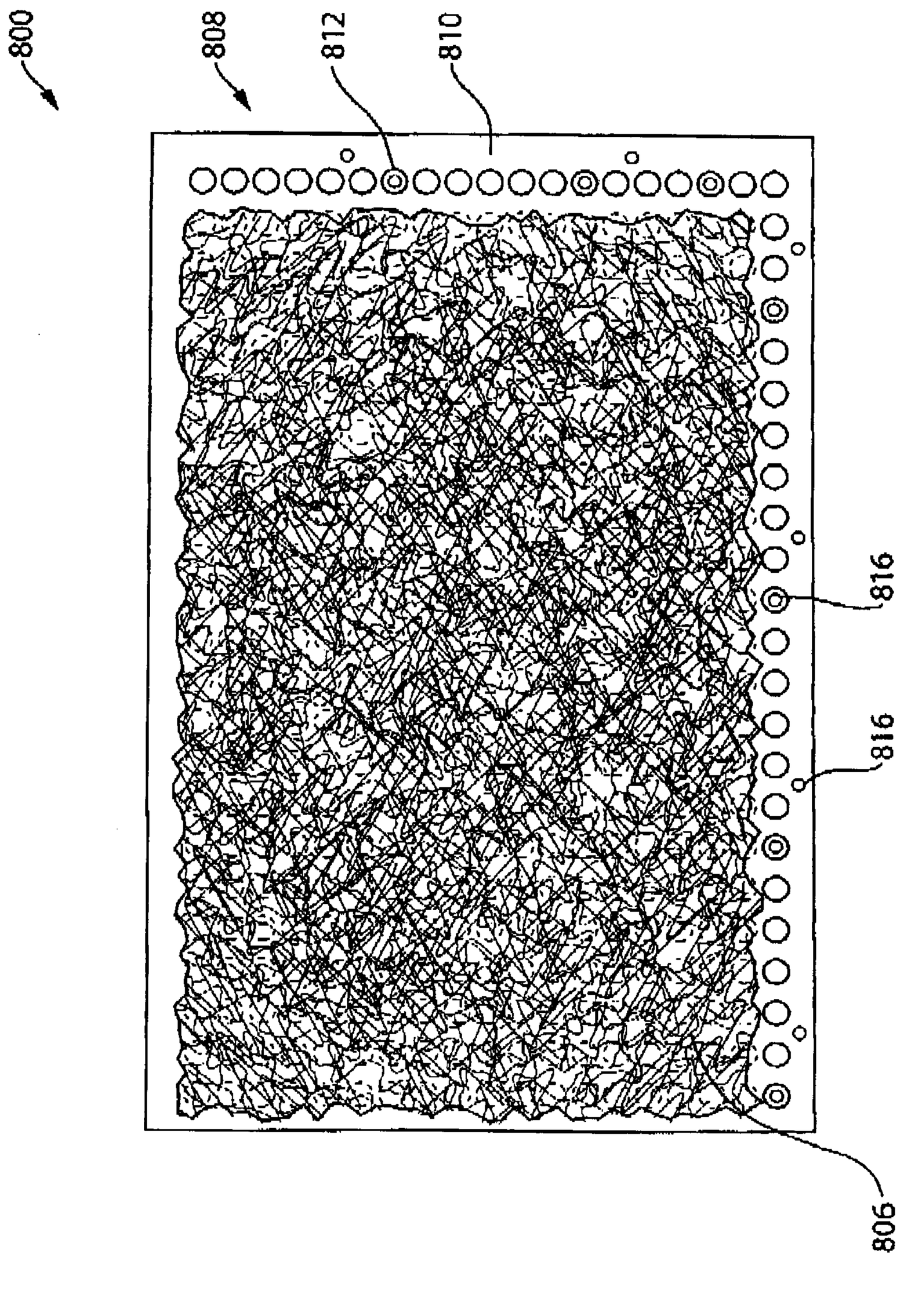


FIG.8

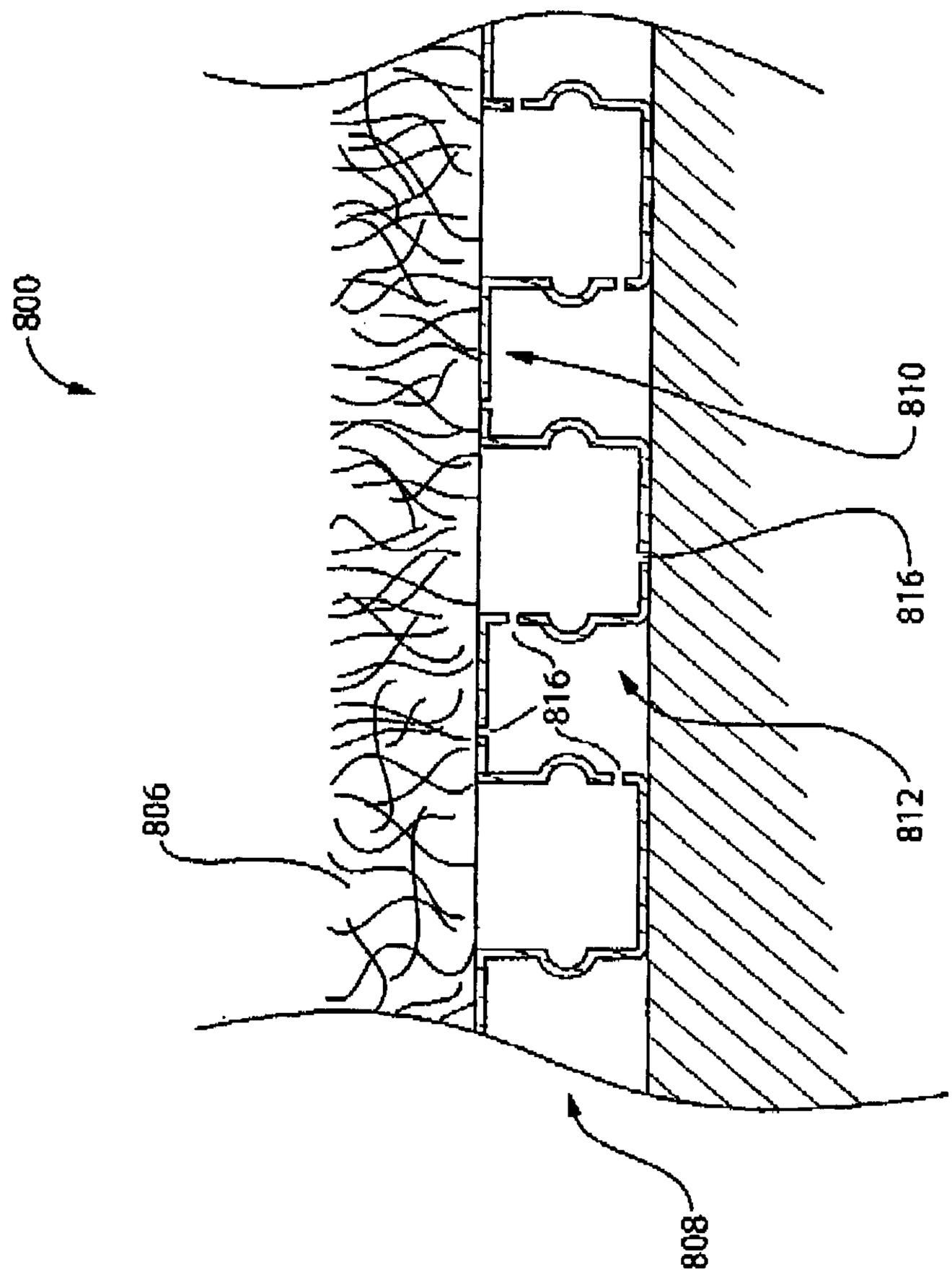


FIG.9

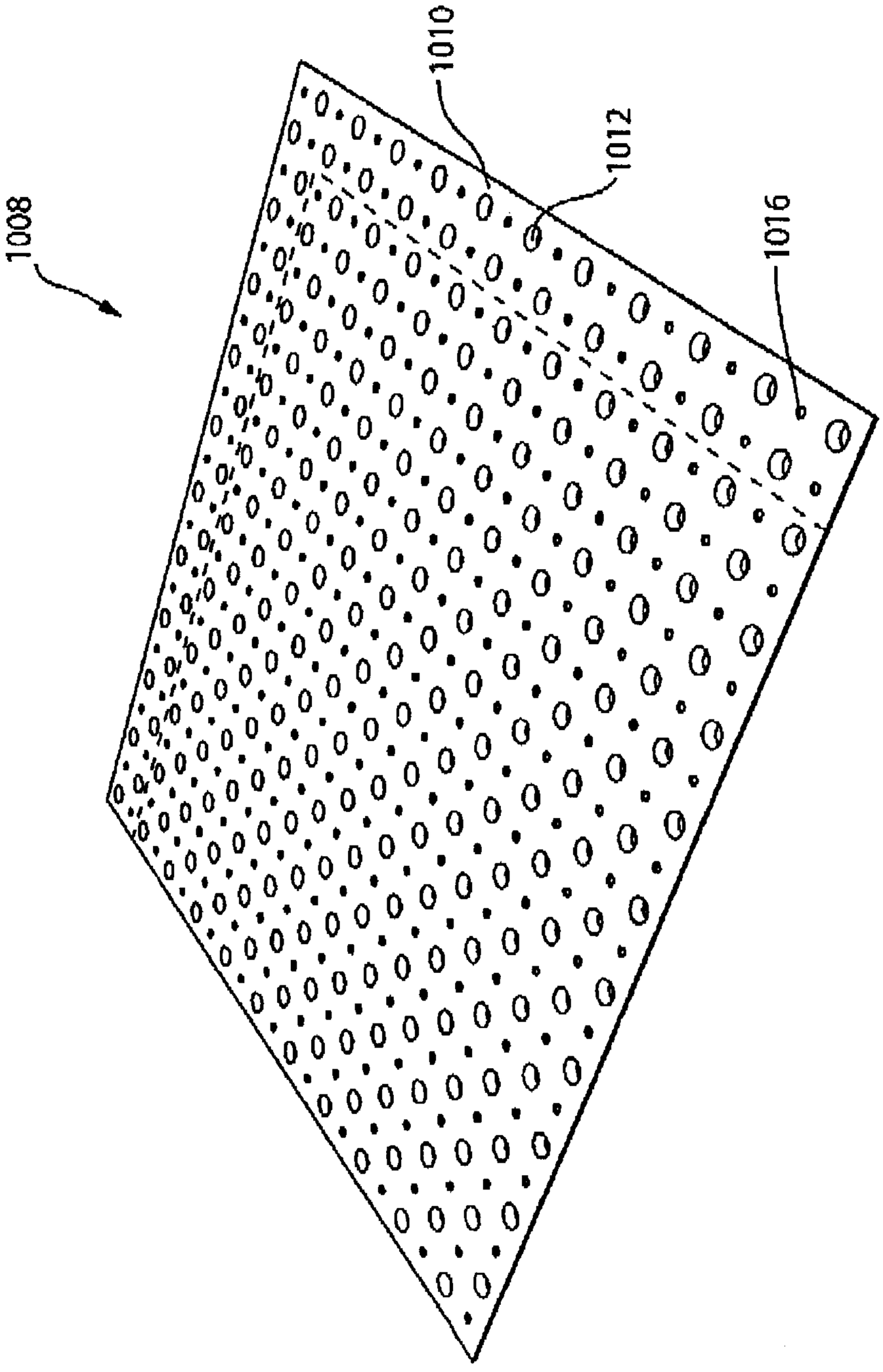


FIG. 10

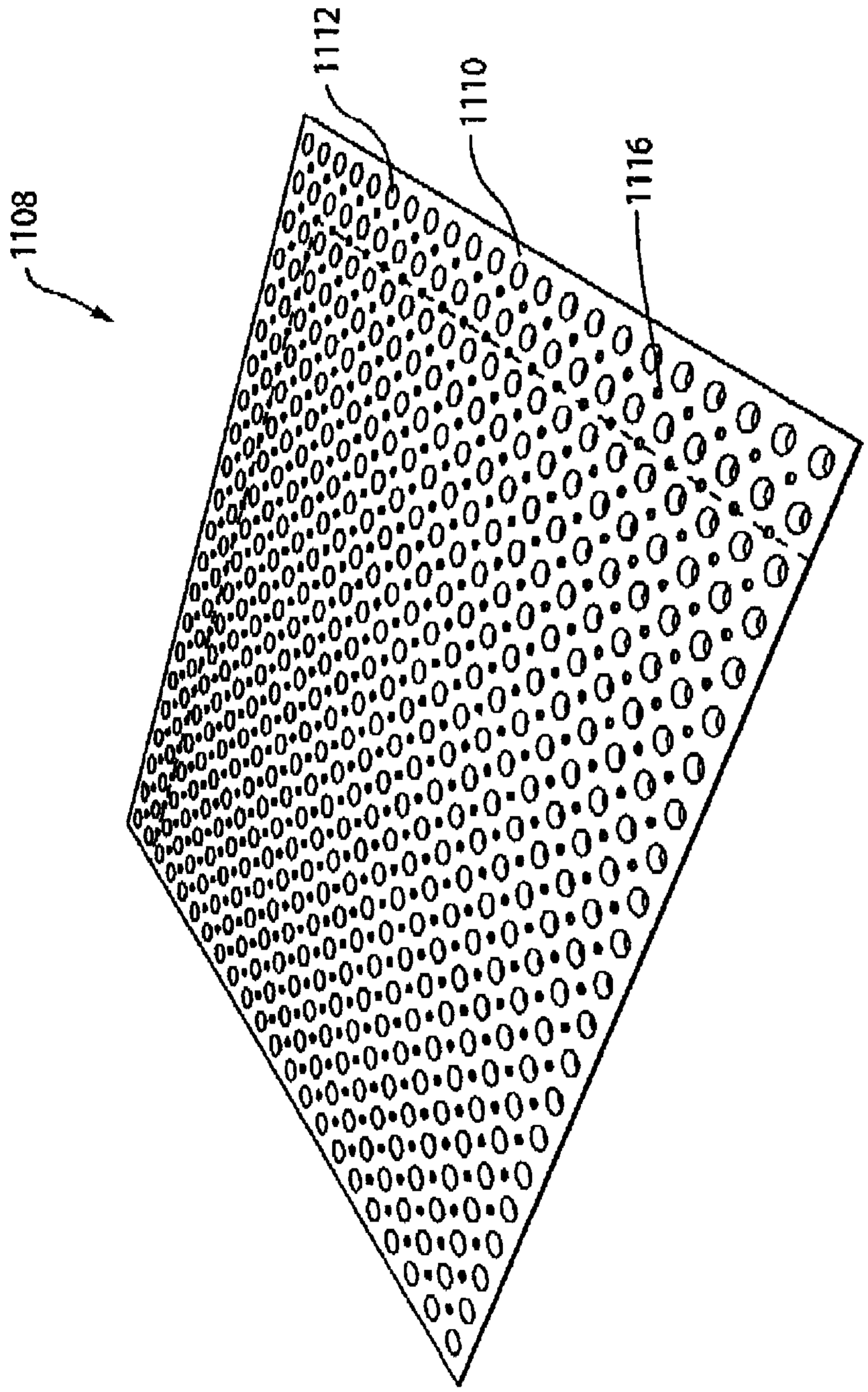


FIG. 11

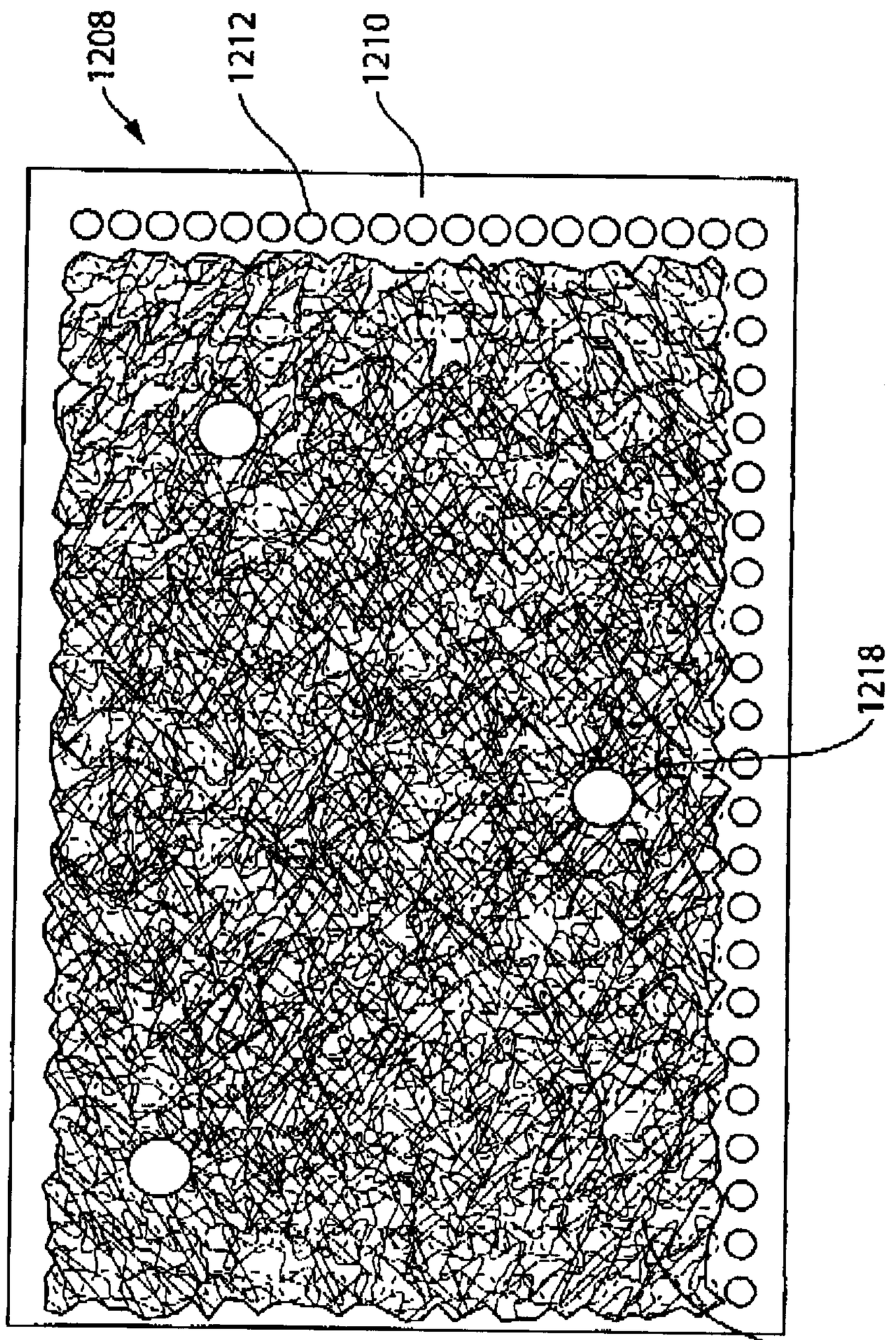
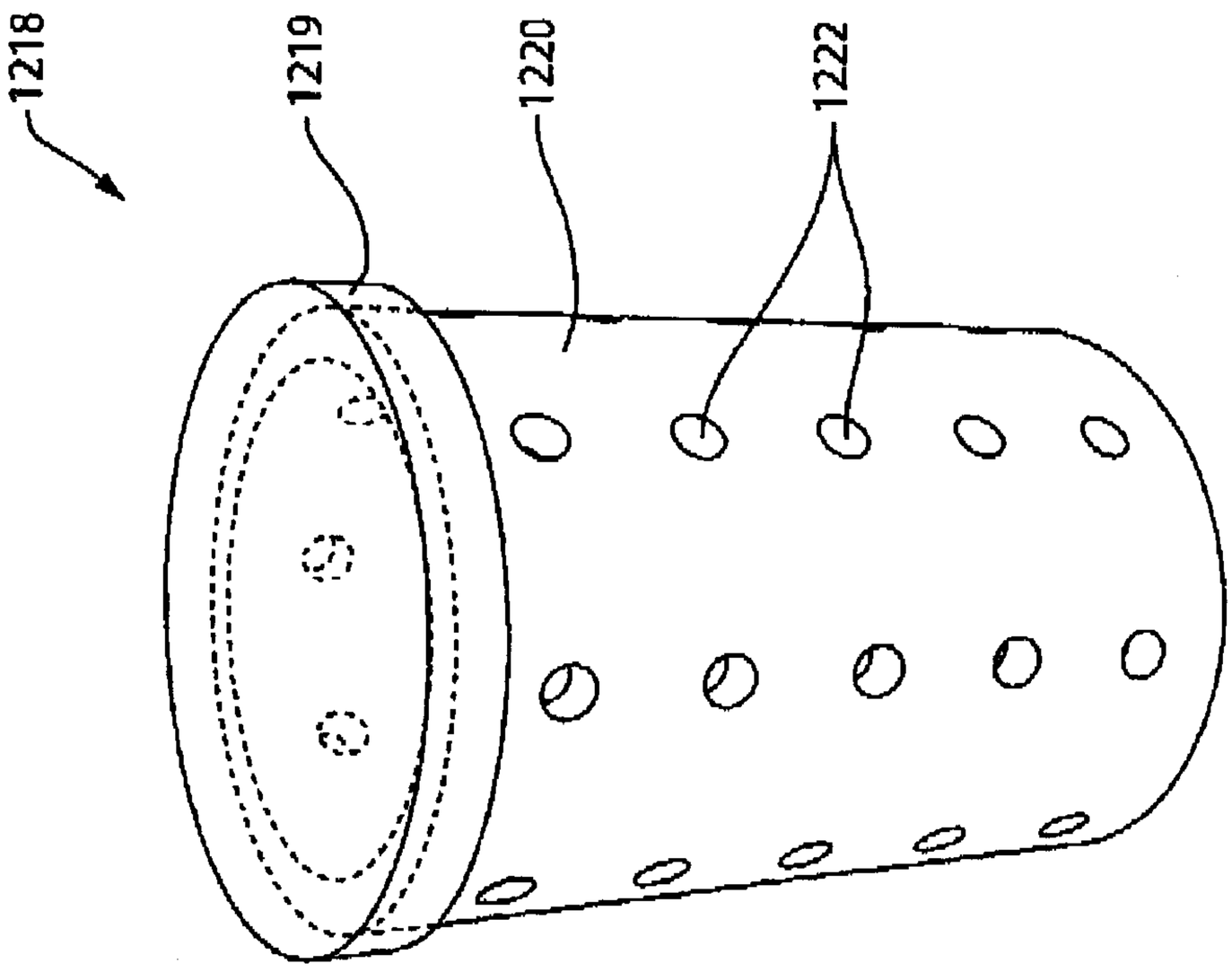


FIG. 12

FIG.13



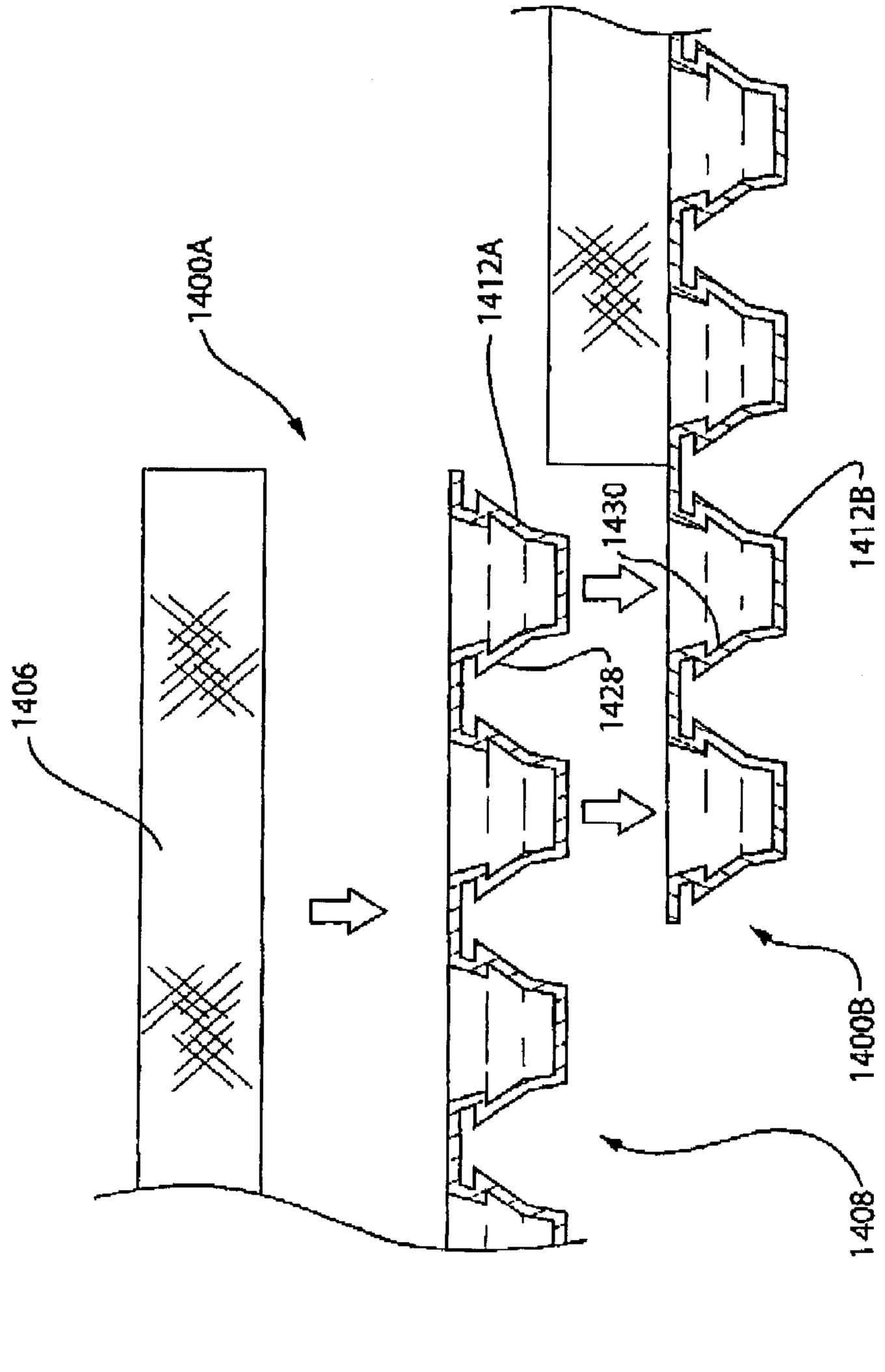


FIG. 14

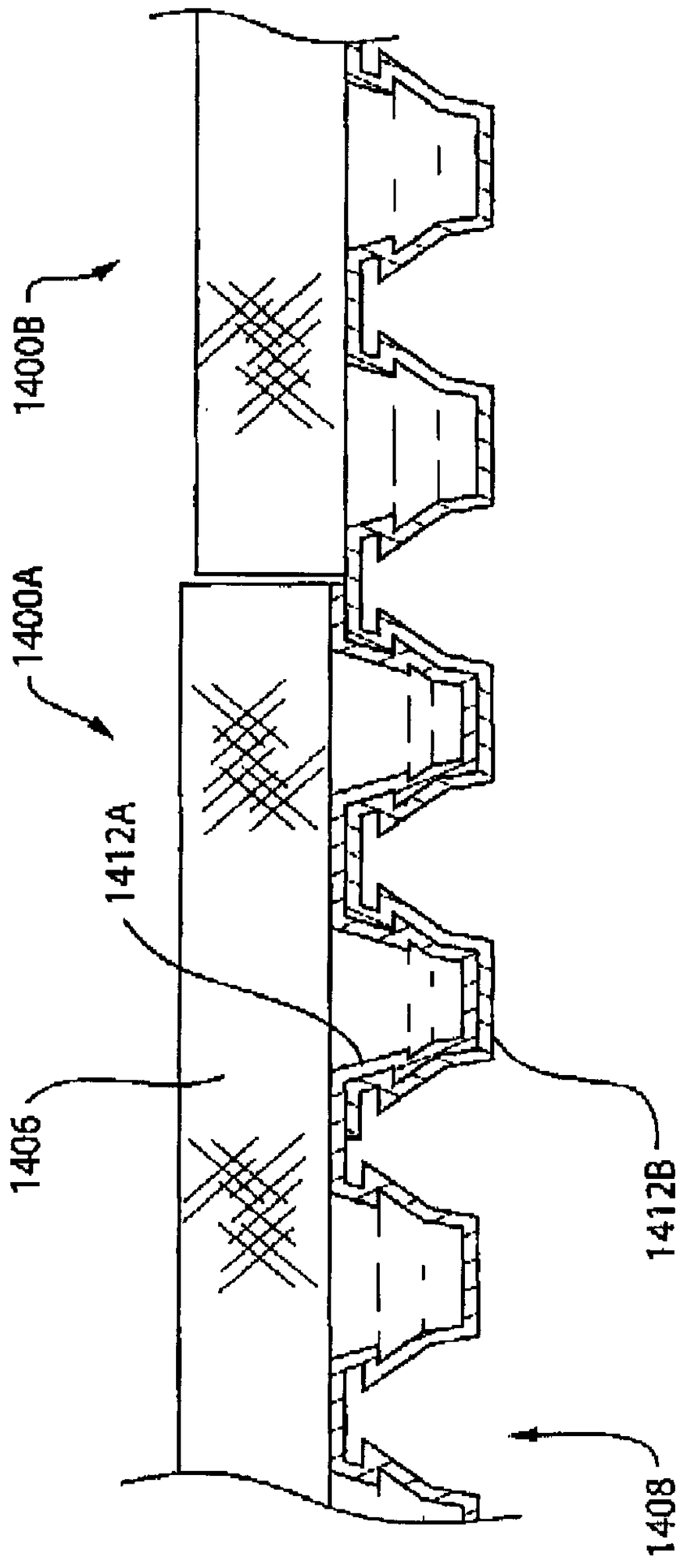


FIG. 15

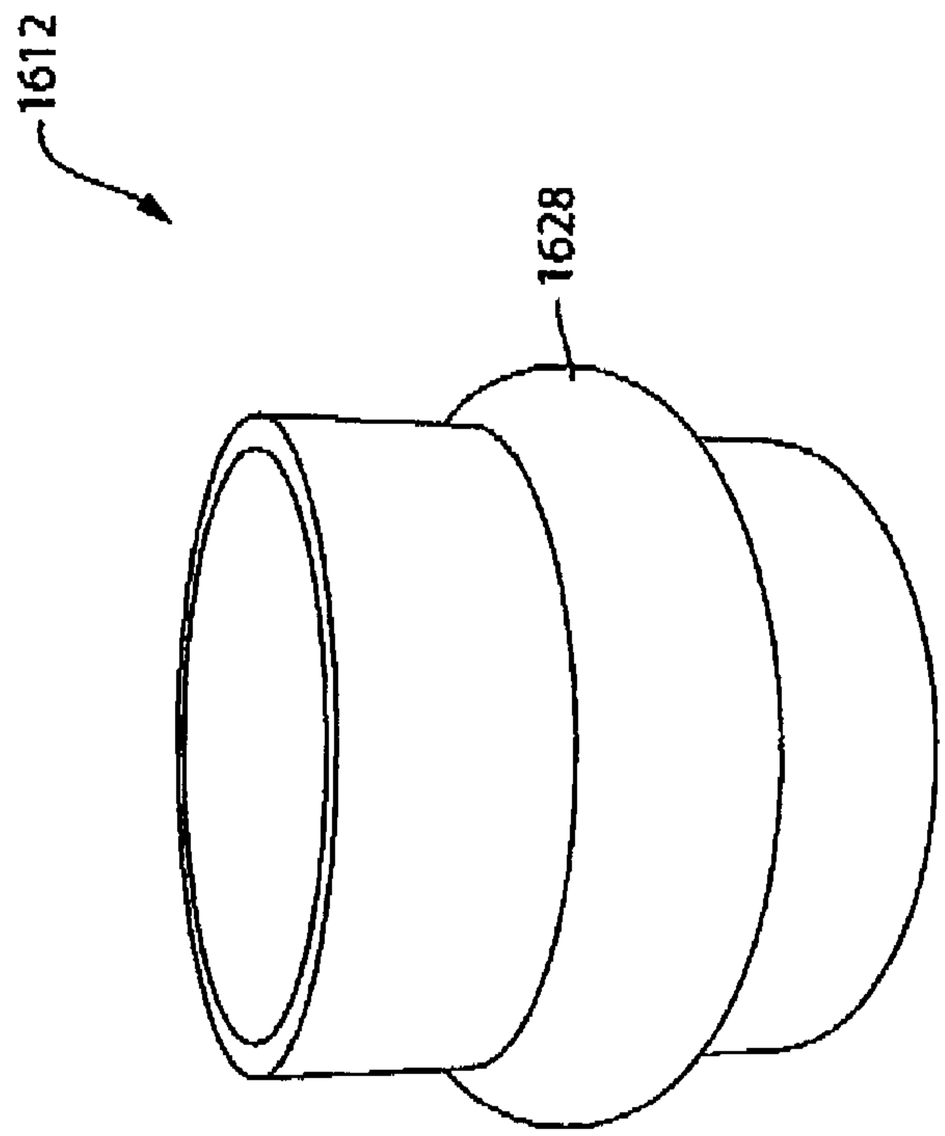
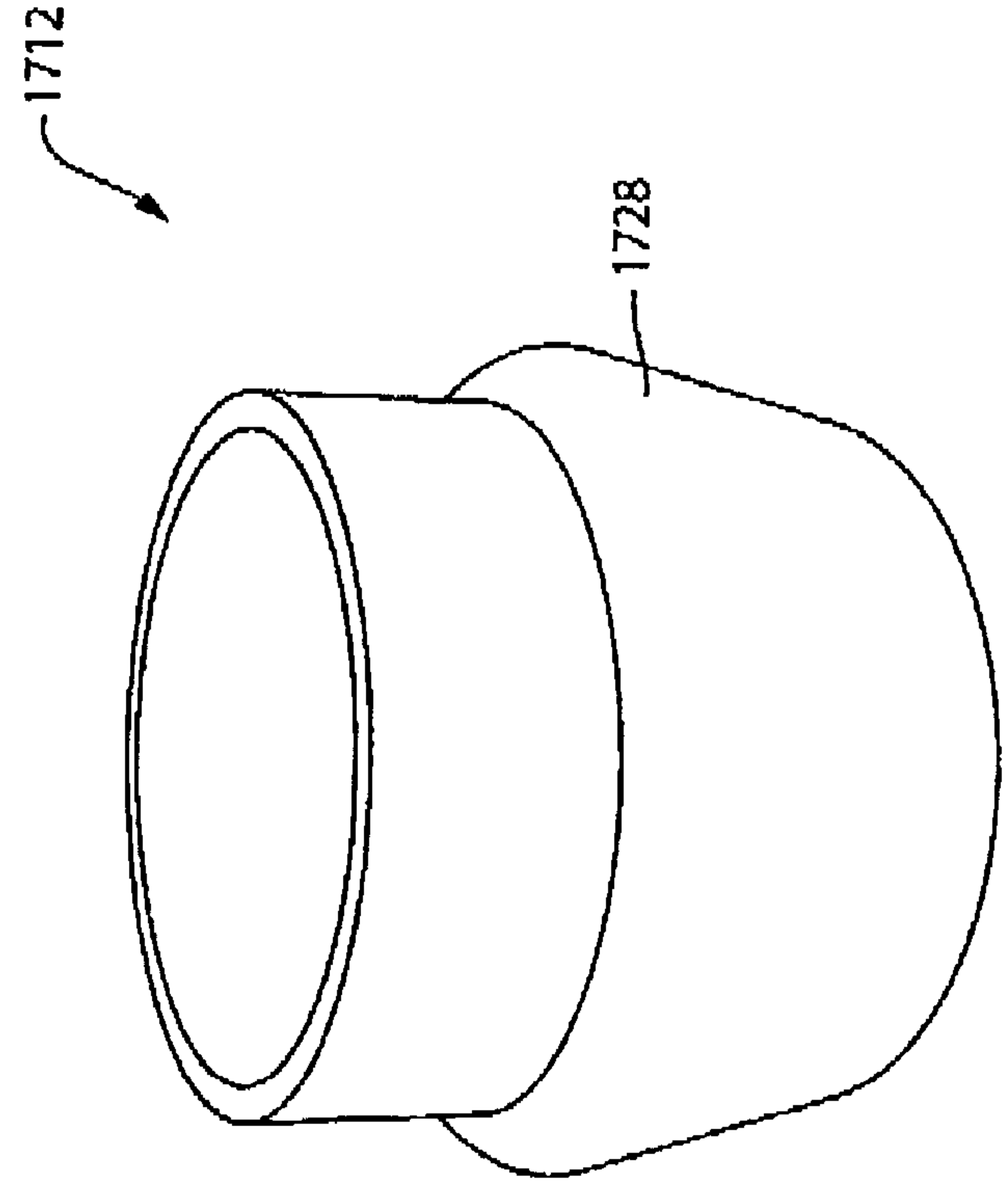


FIG.16

FIG. 17



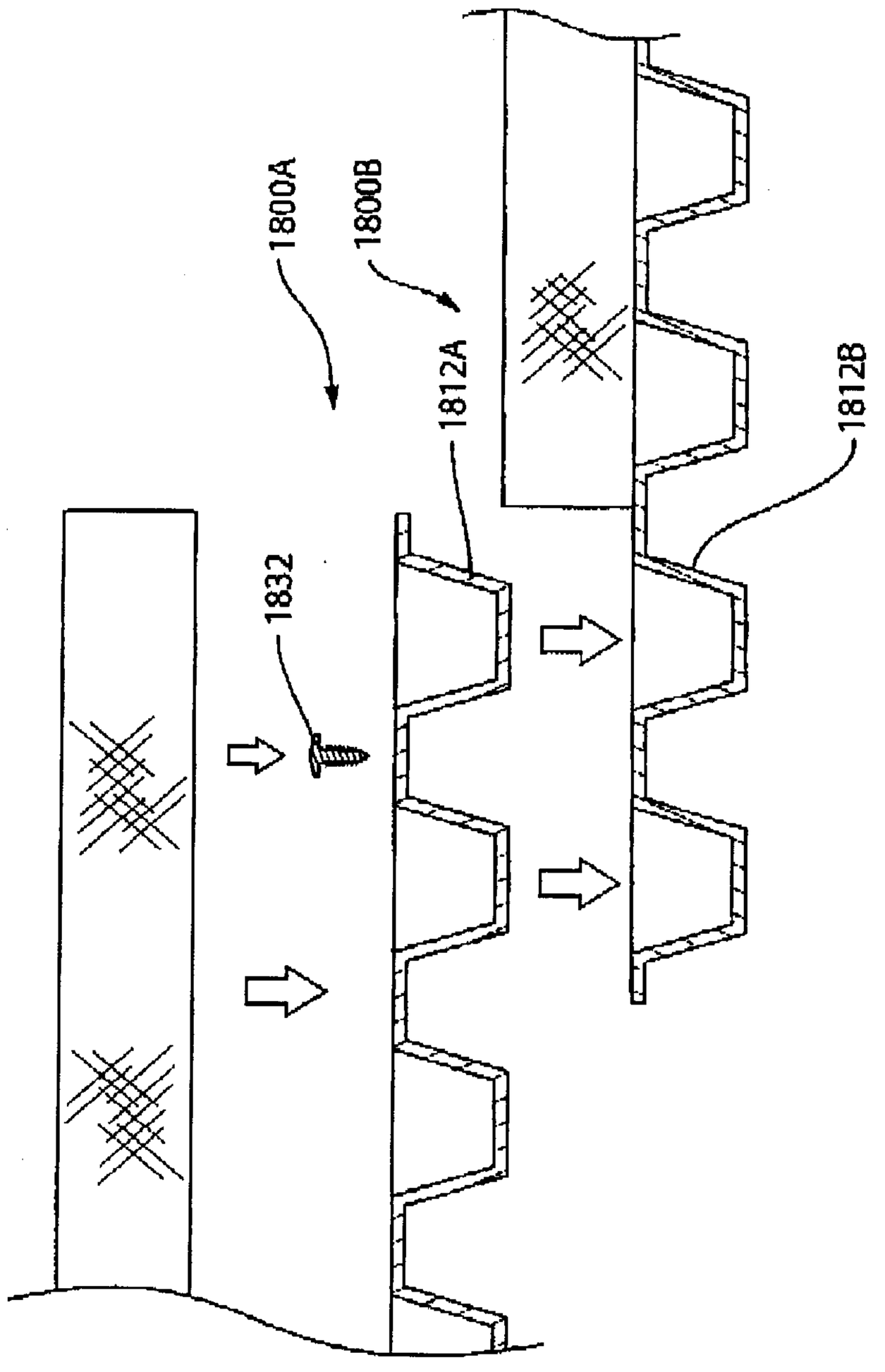


FIG.18

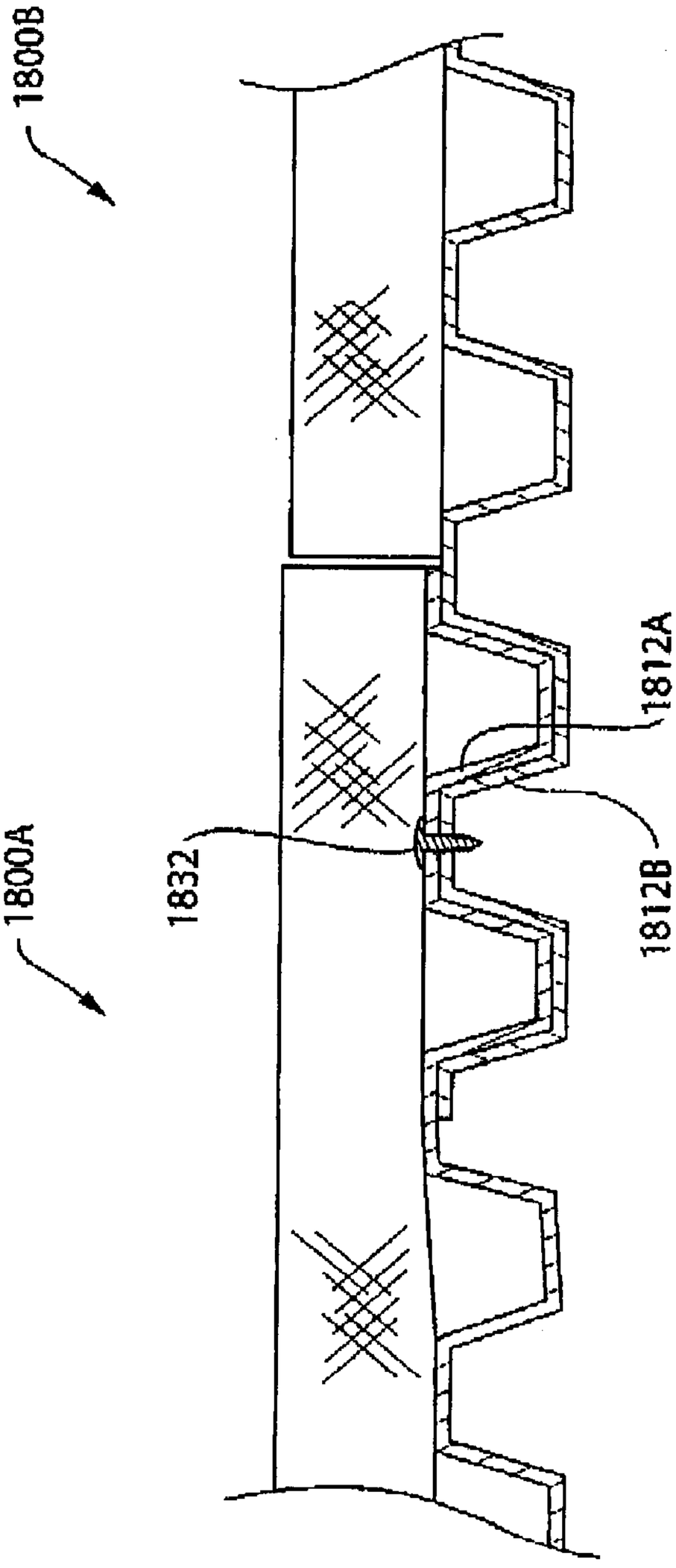
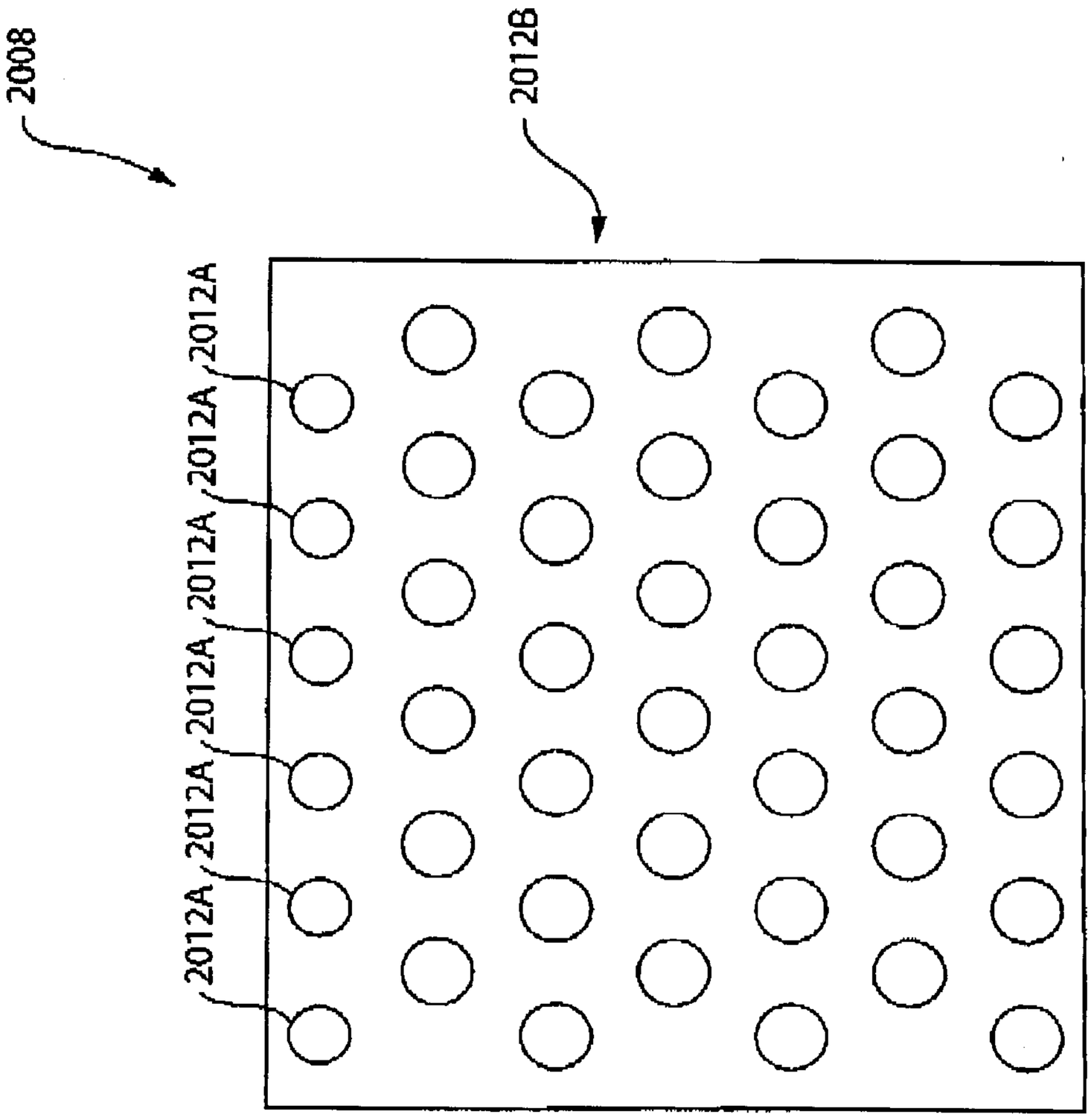


FIG. 19

FIG.20



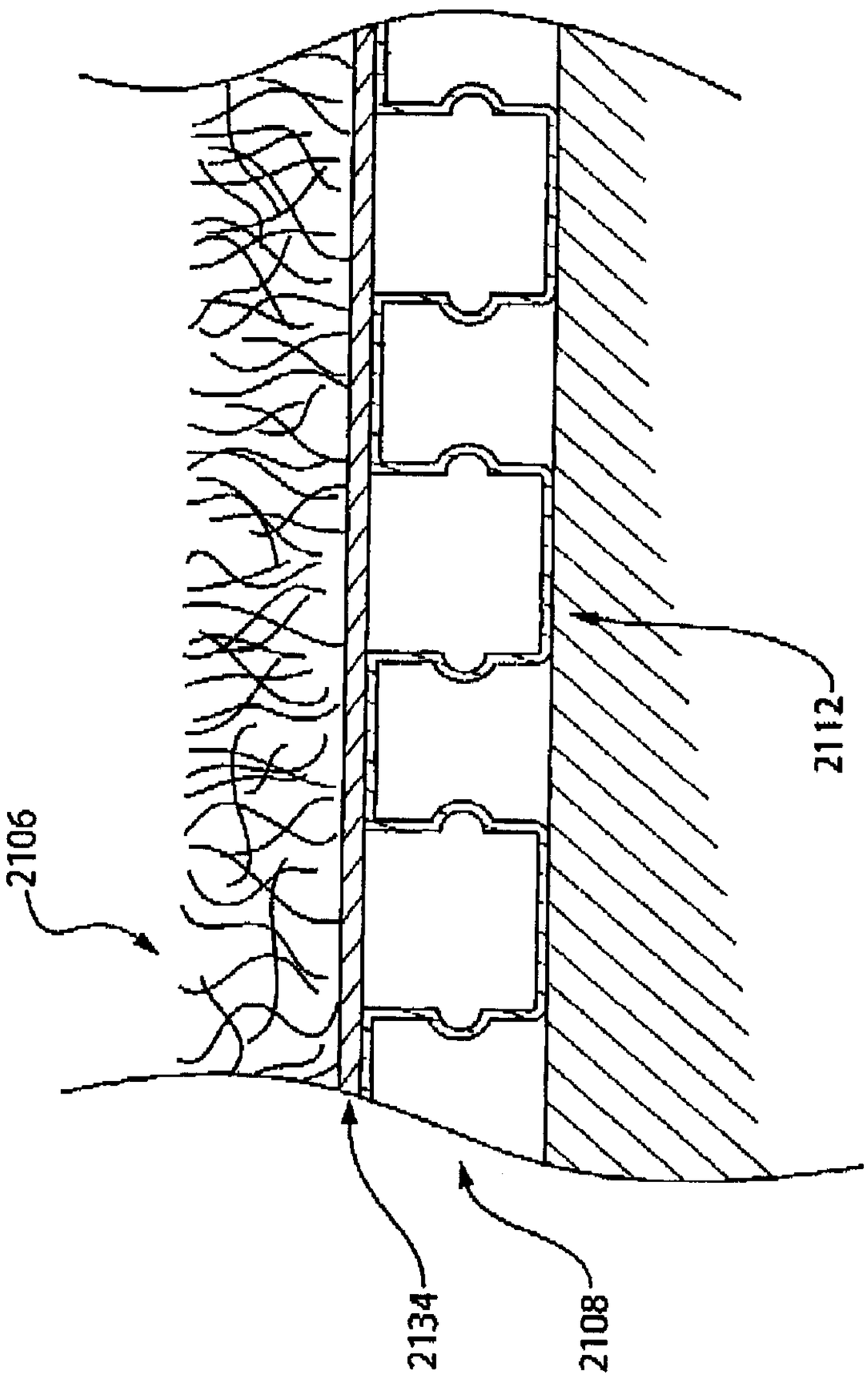


FIG. 21

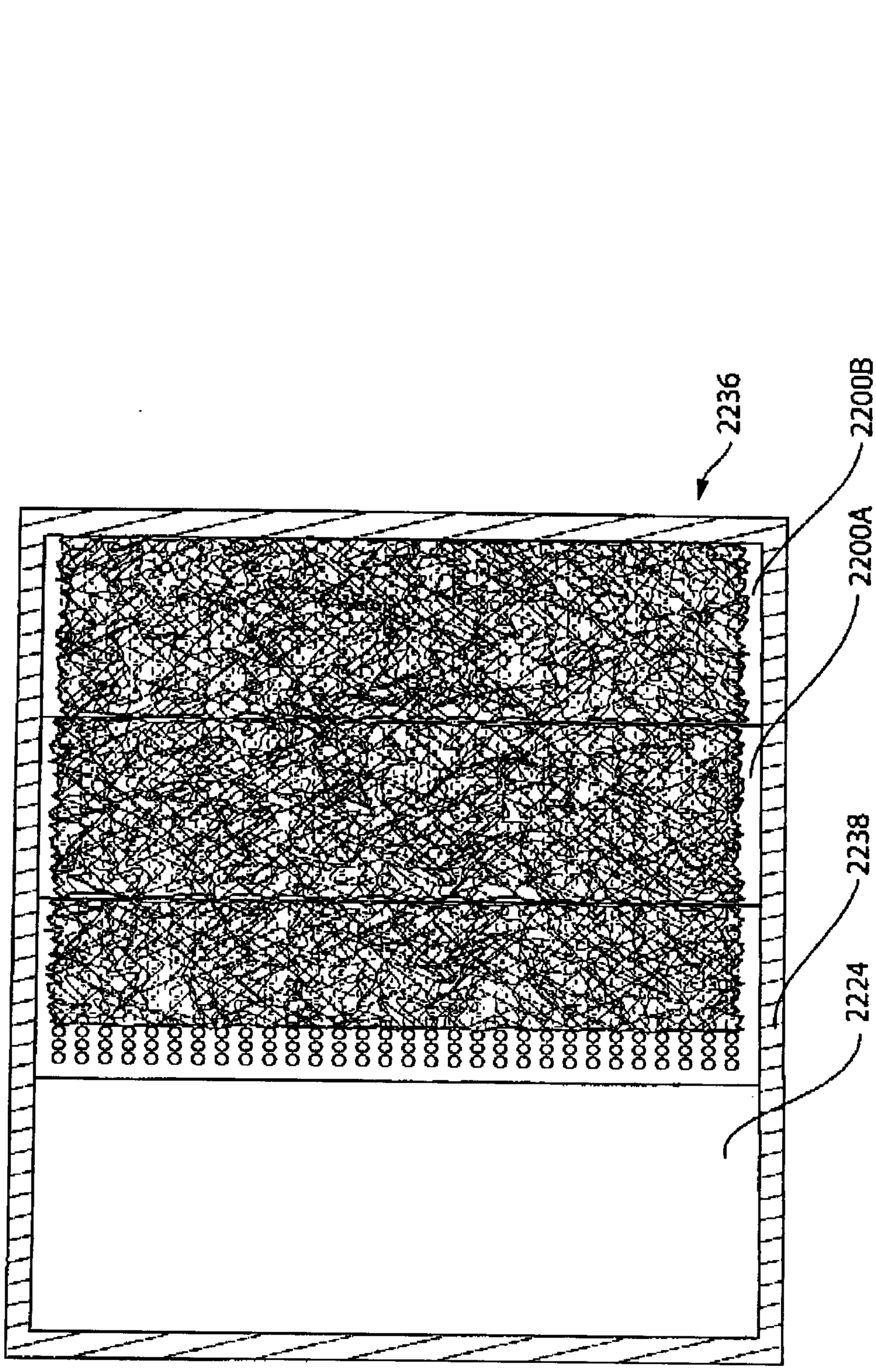
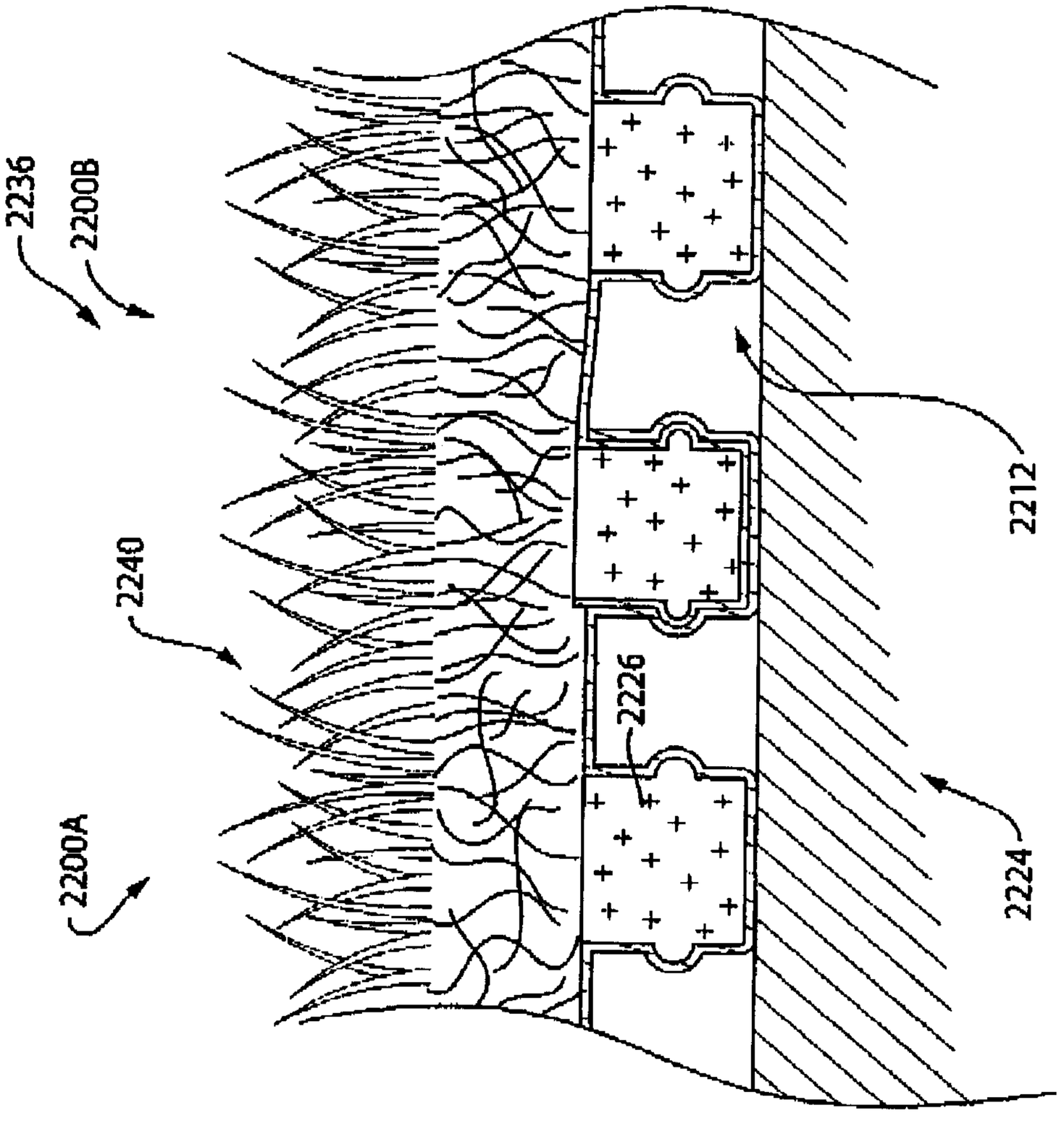


FIG. 22

FIG. 23



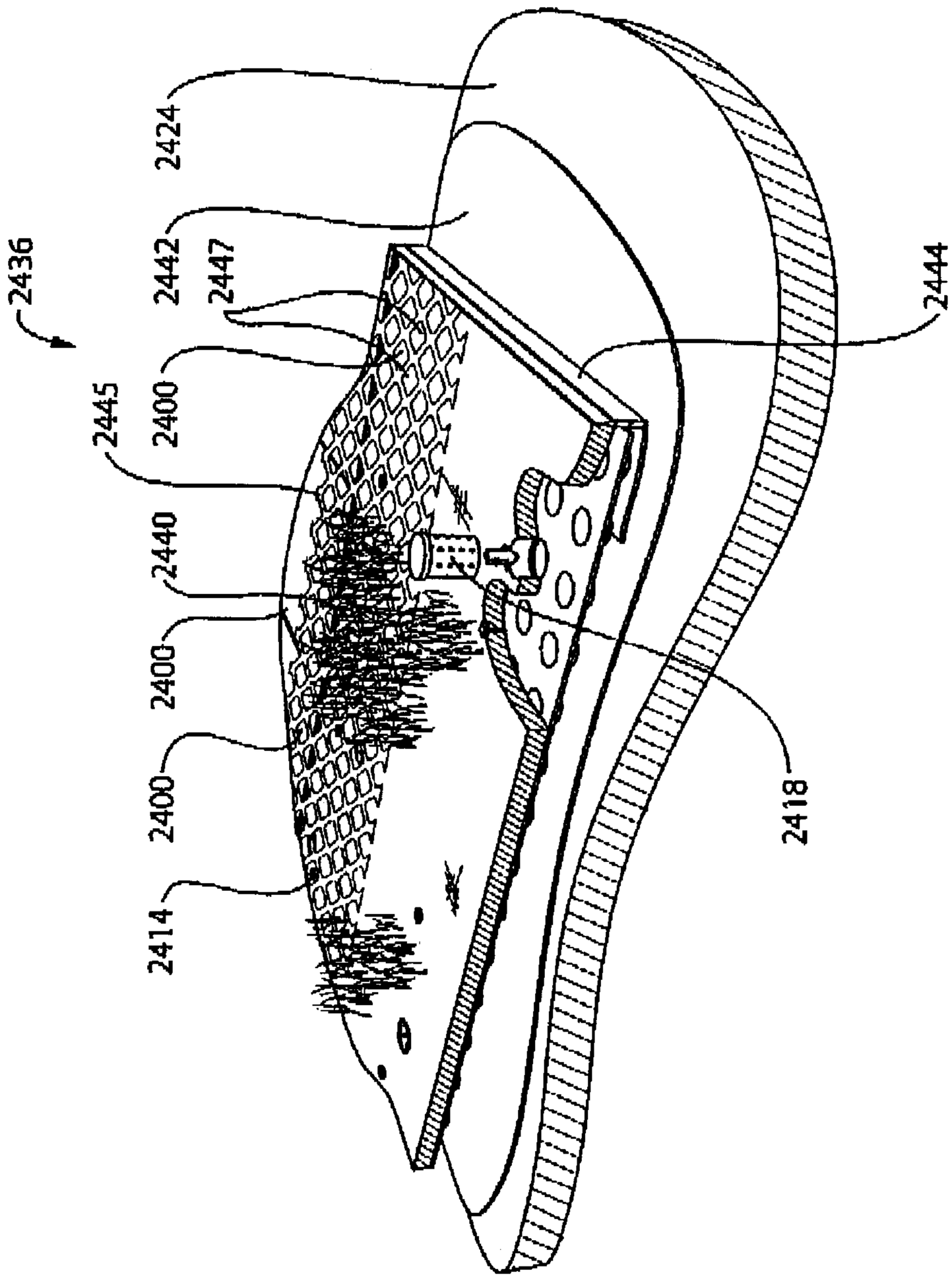


FIG. 24

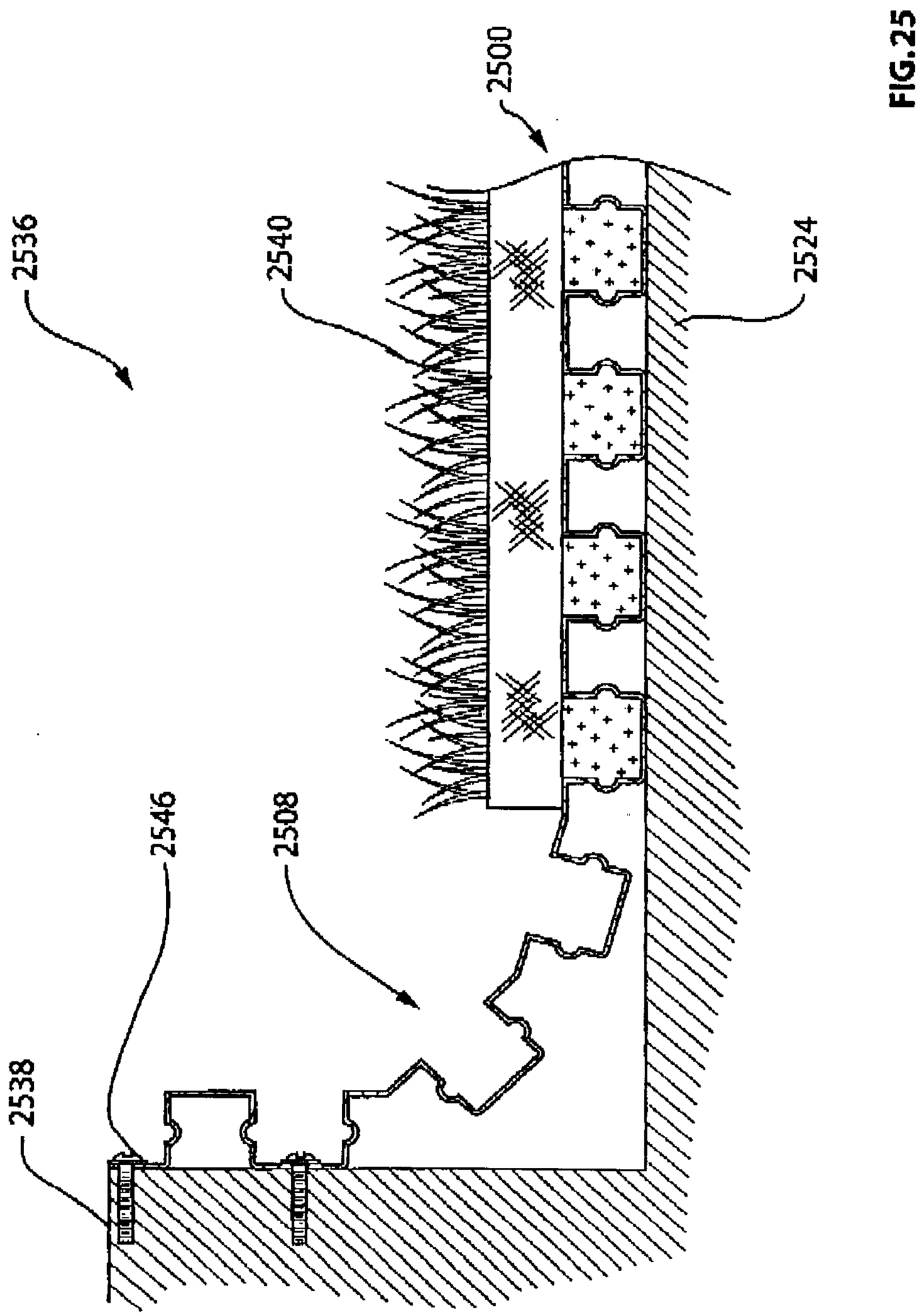


FIG.25

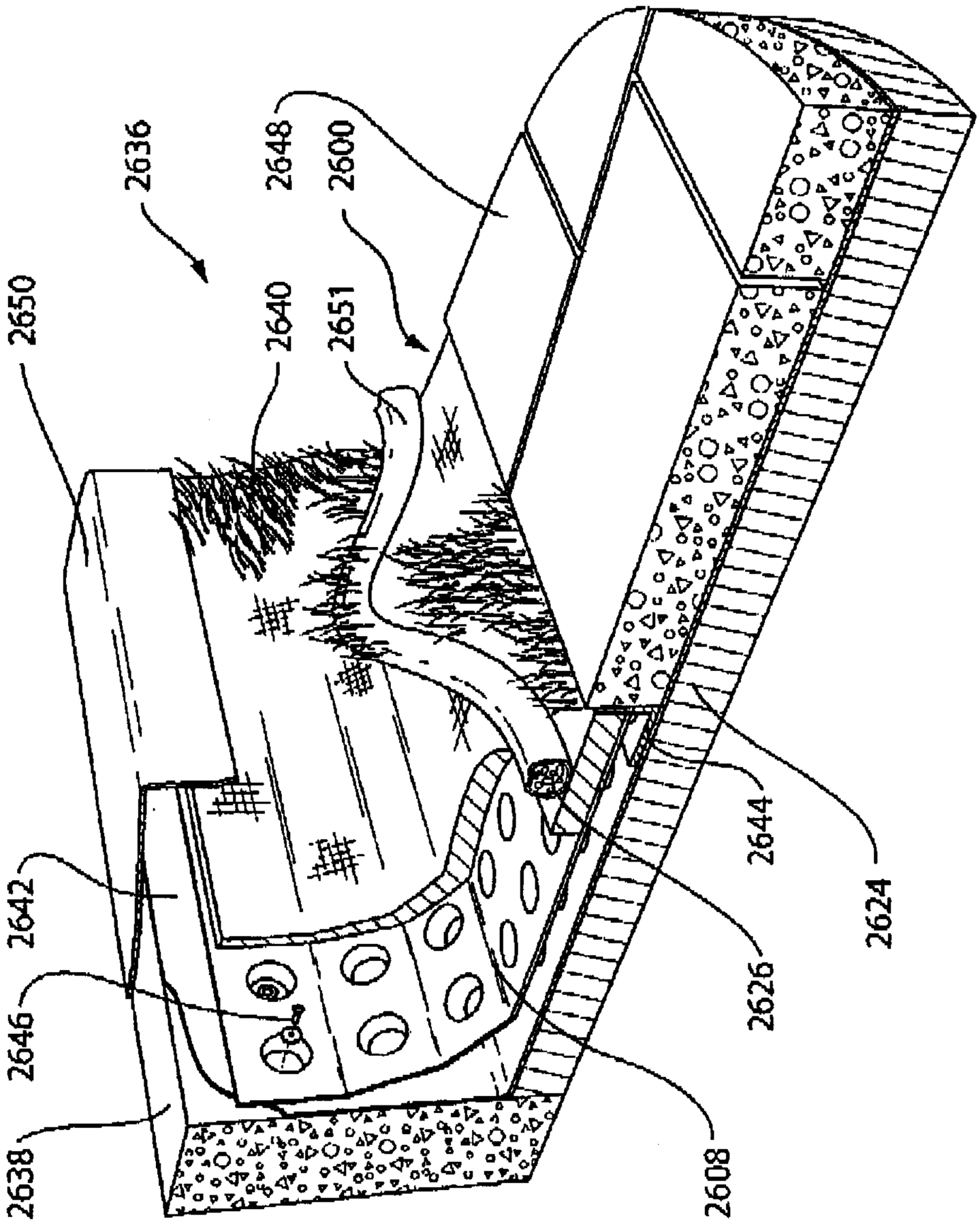

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FIG.26

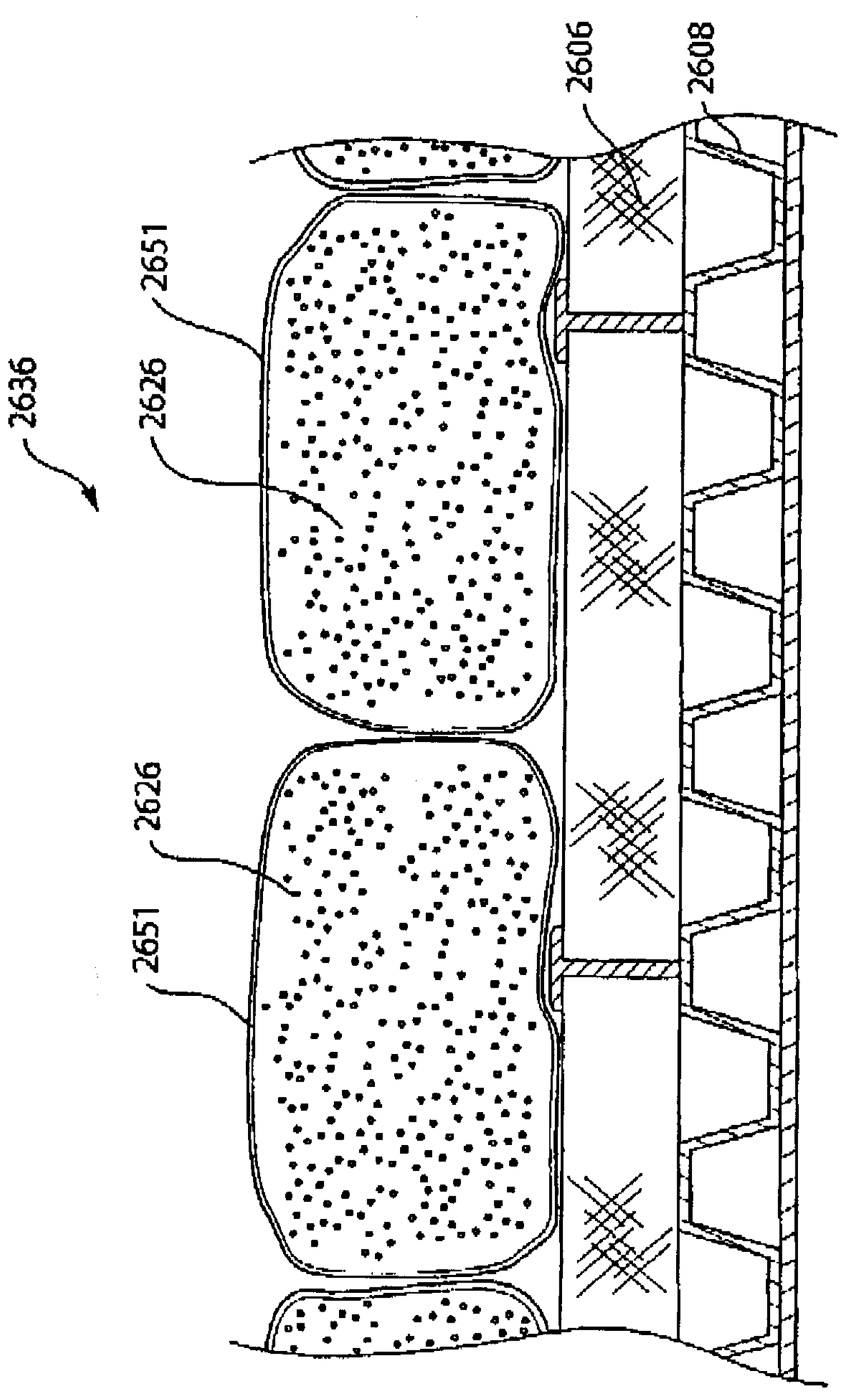


FIG. 26B

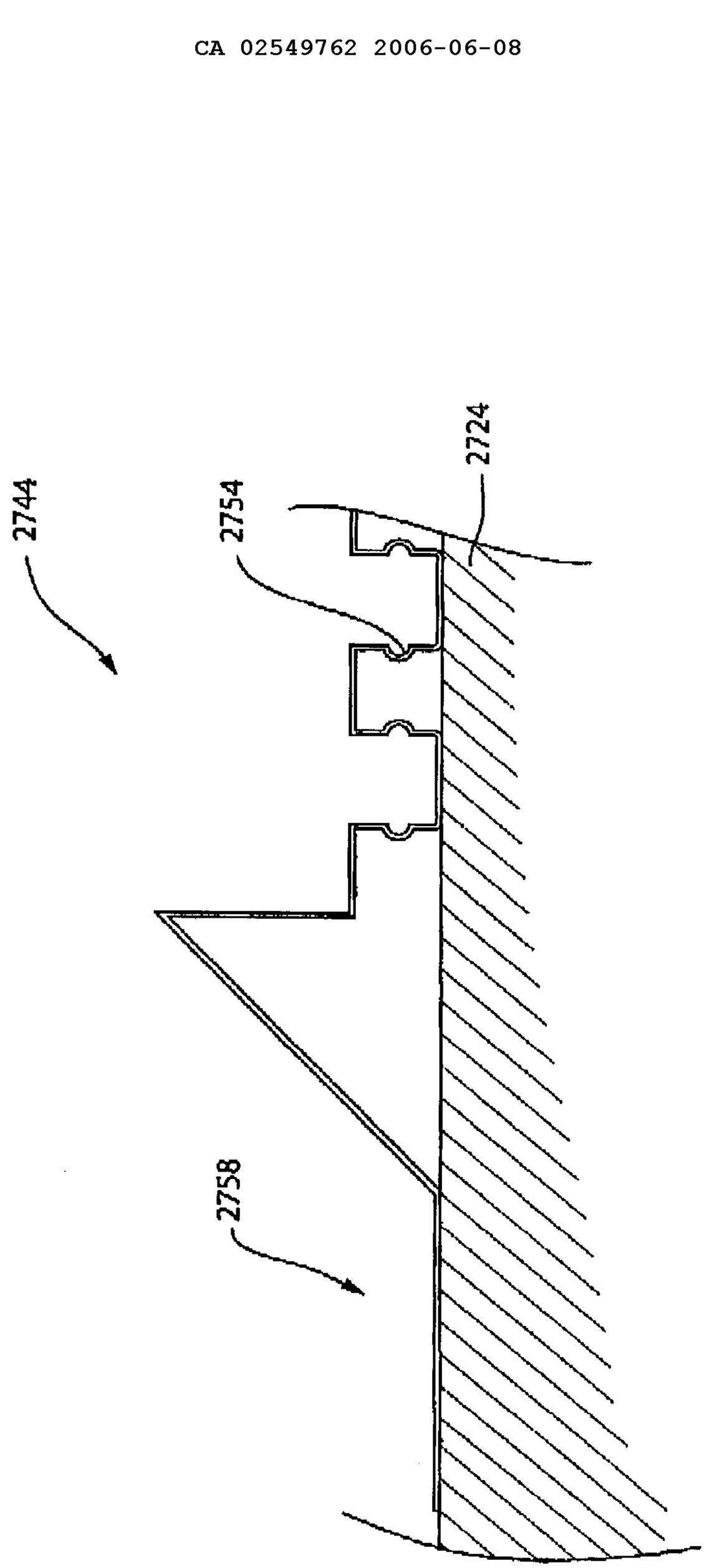


FIG.27

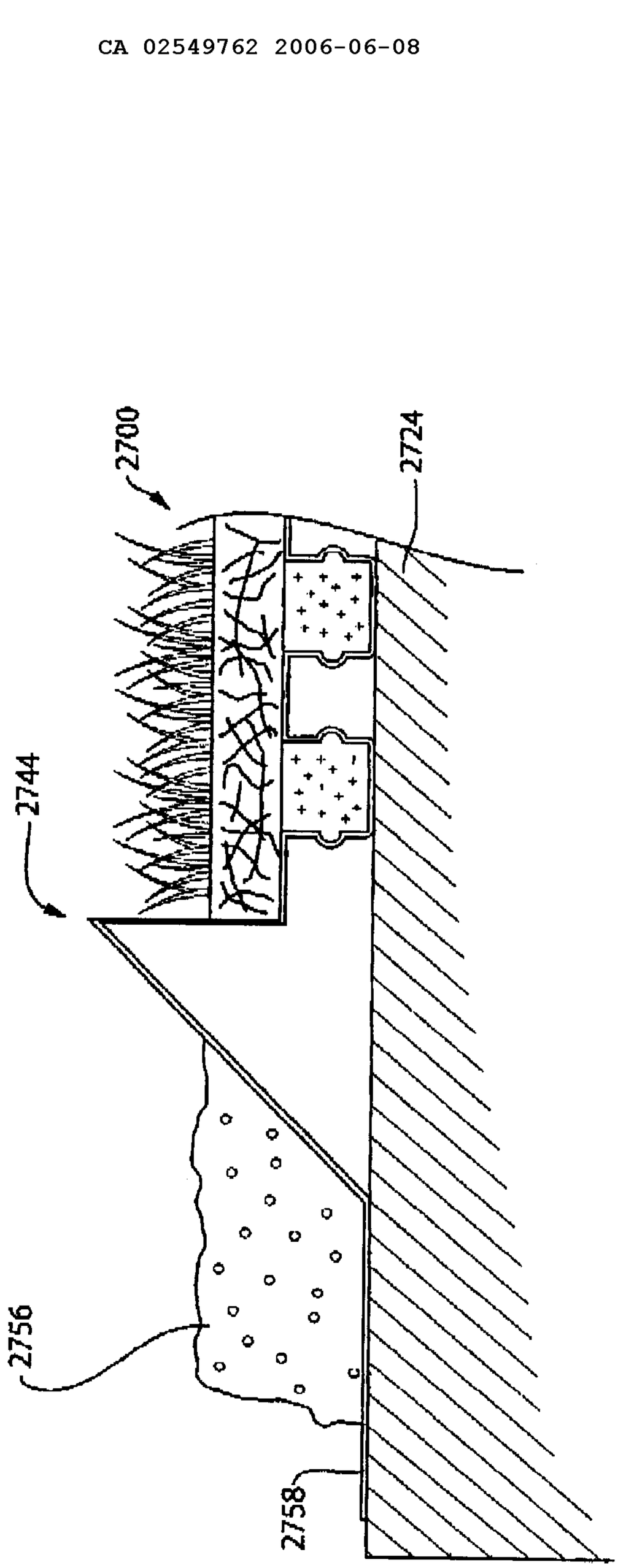
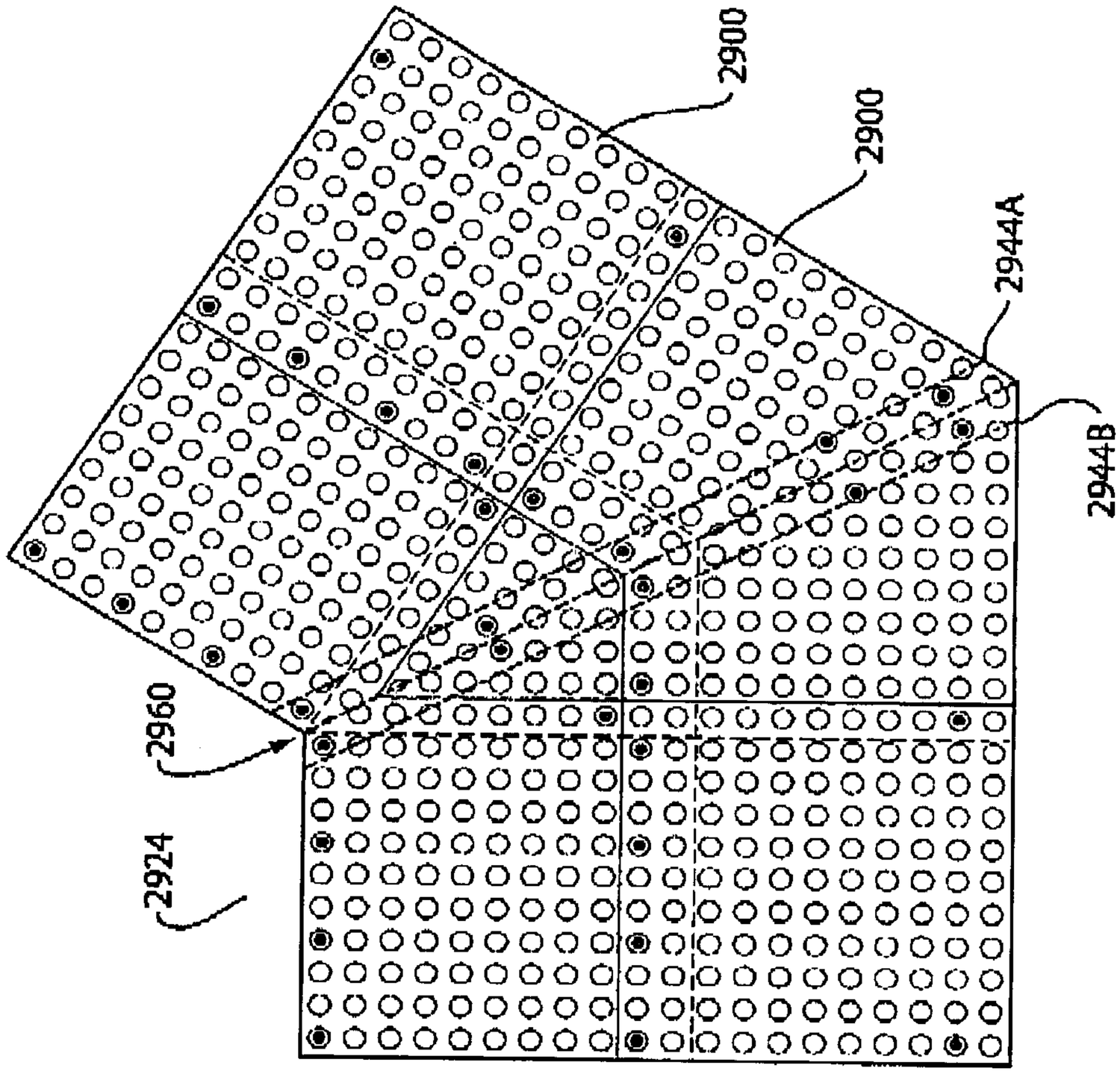


FIG. 28

FIG. 29



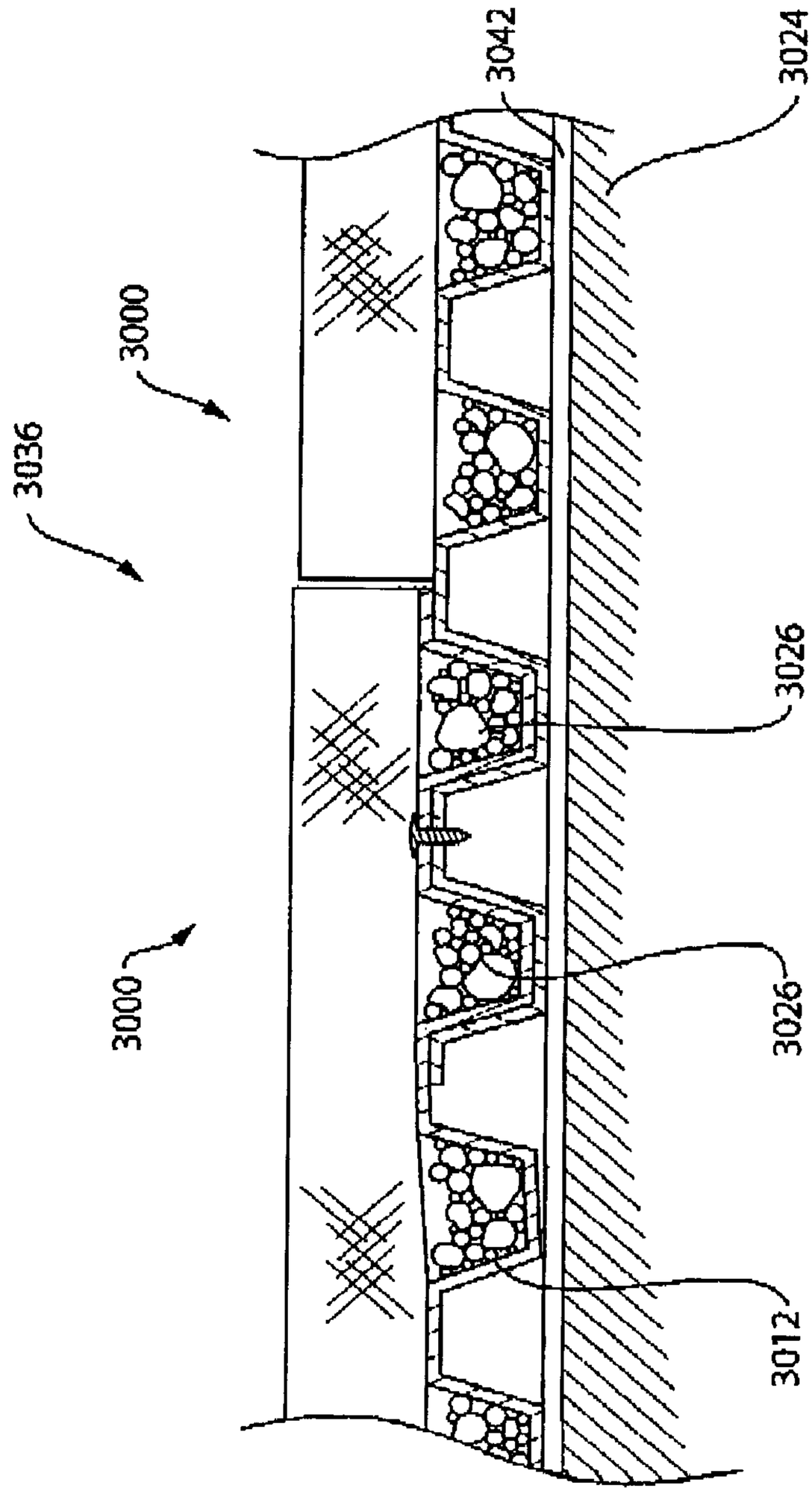


FIG.30

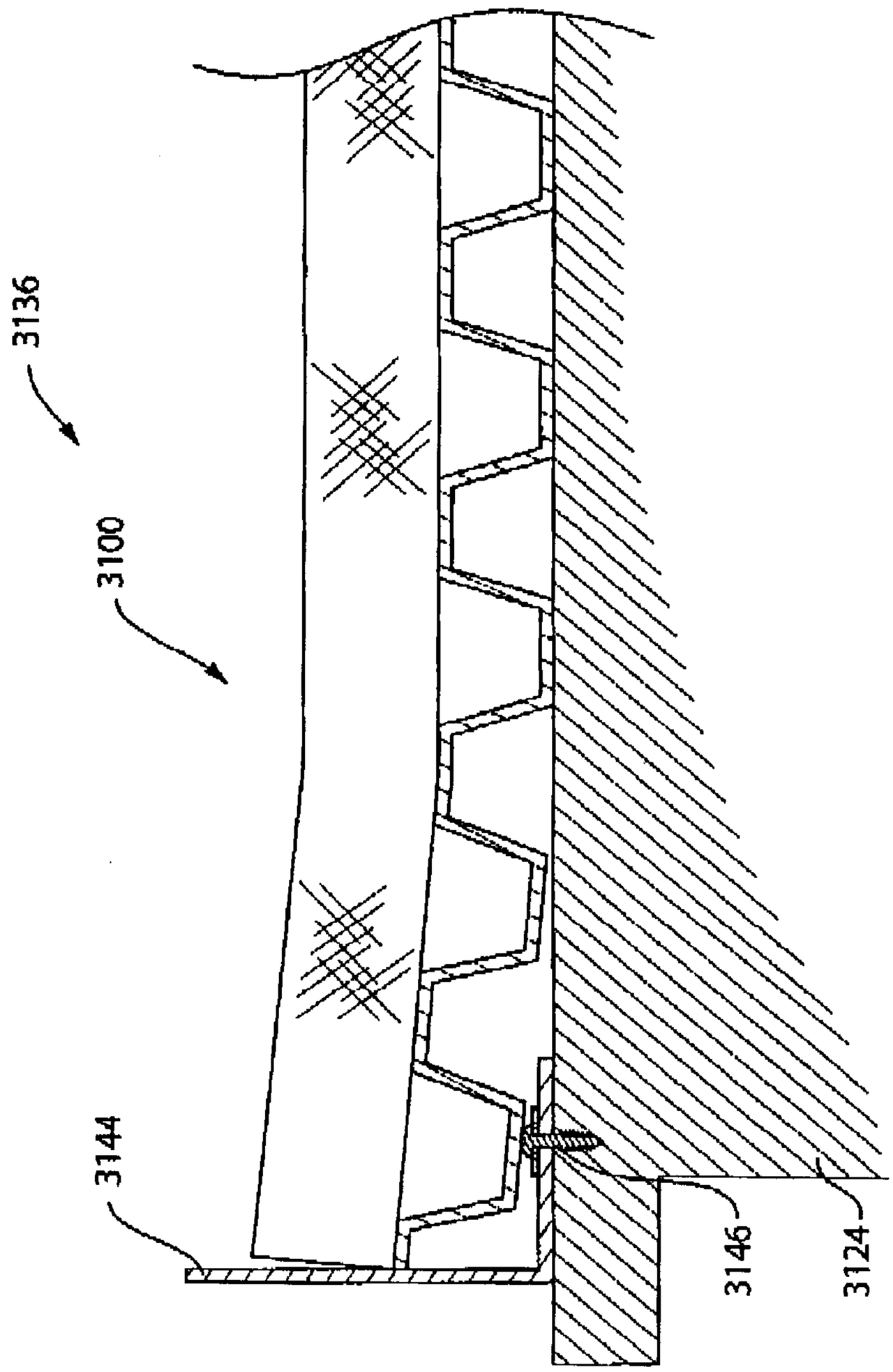


FIG.31

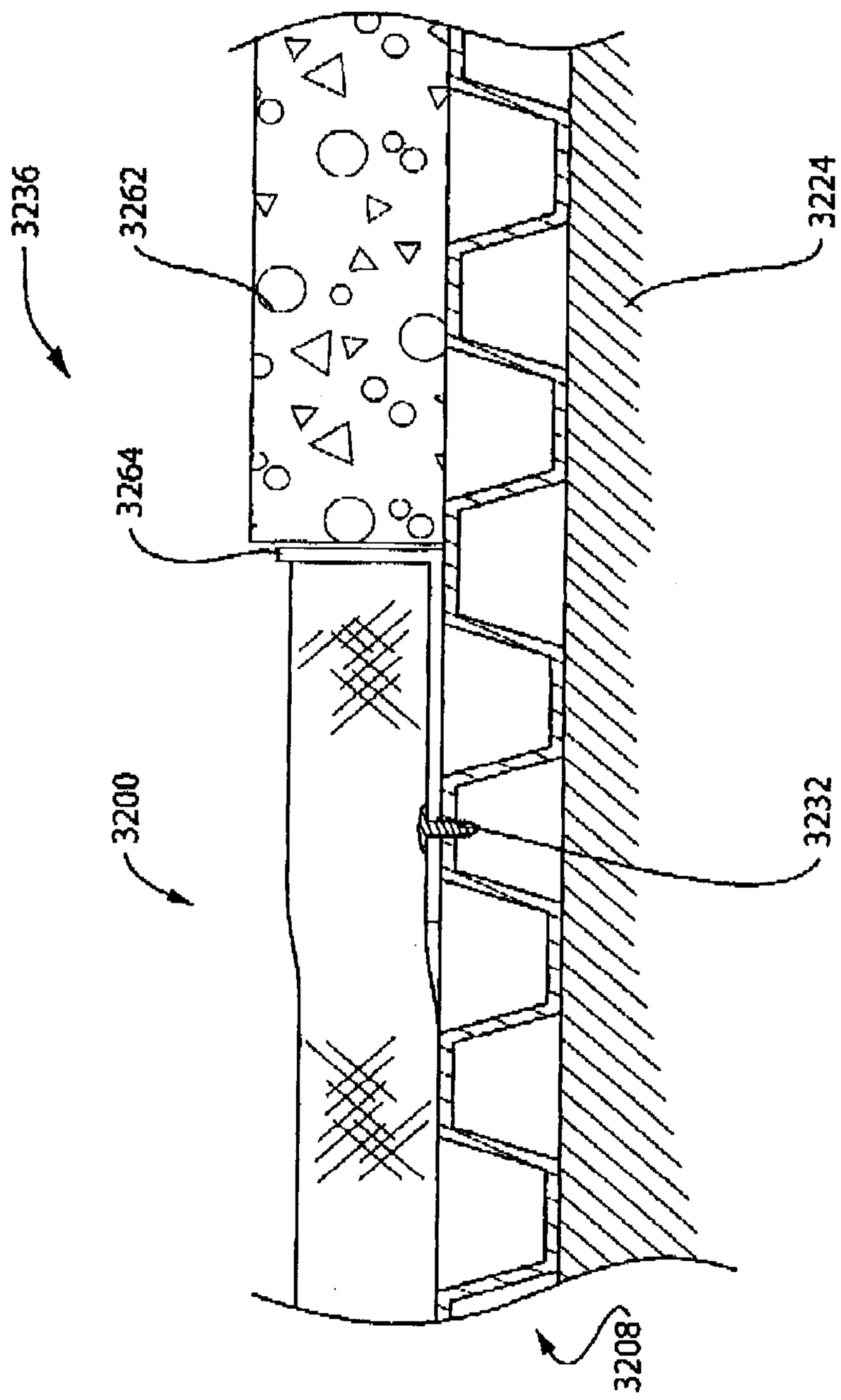


FIG. 32

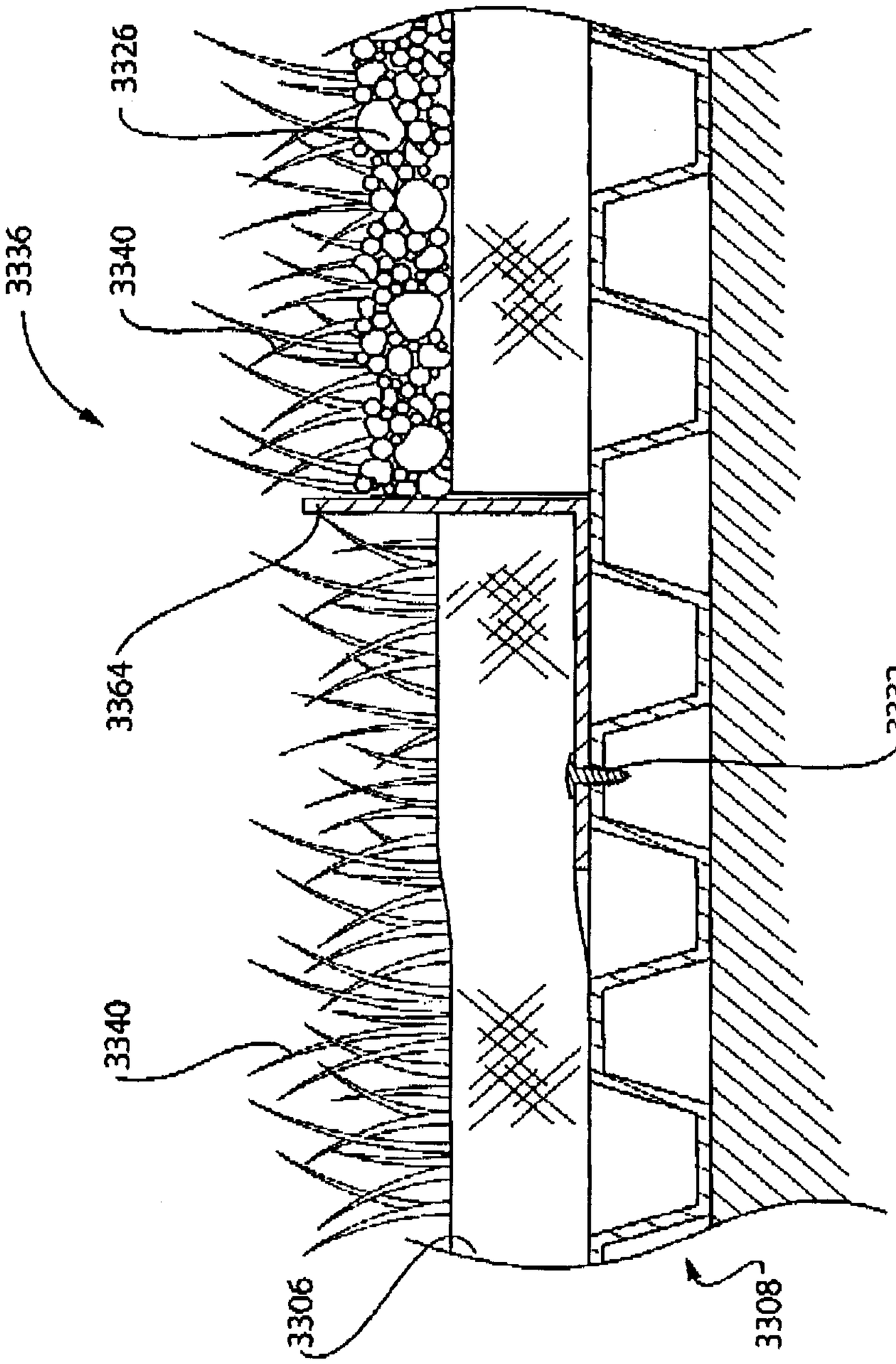


FIG. 33

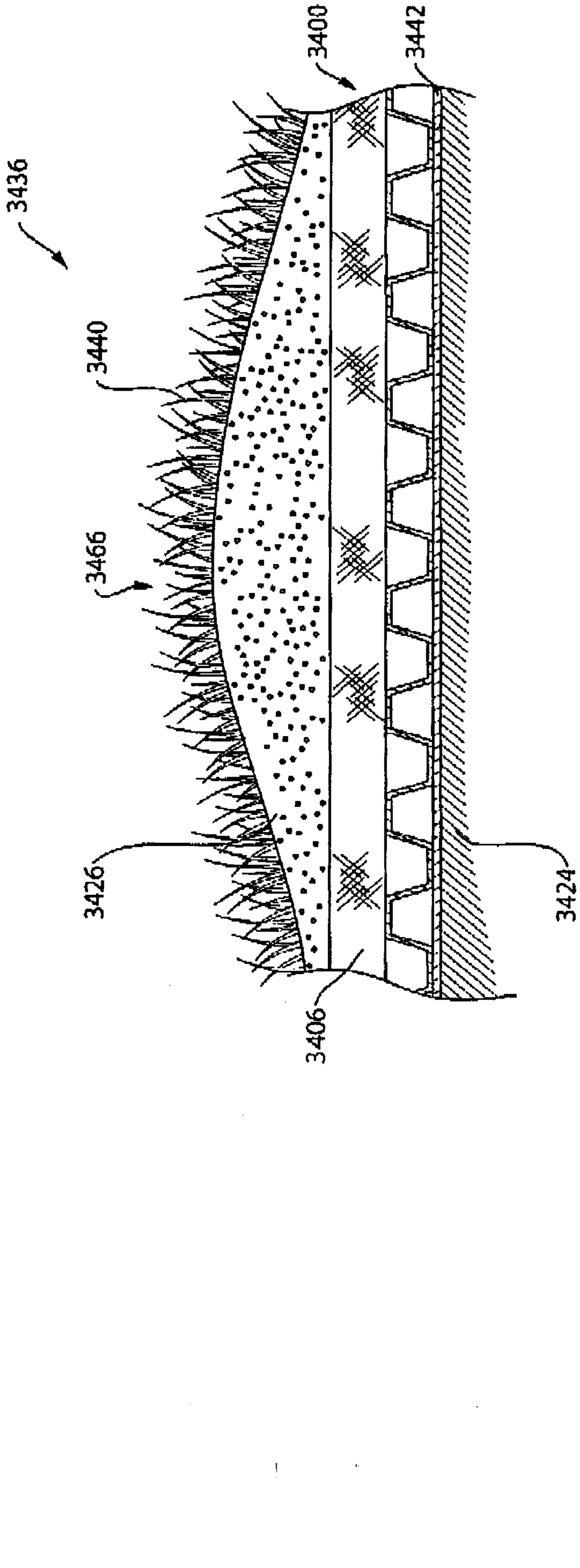


FIG.34

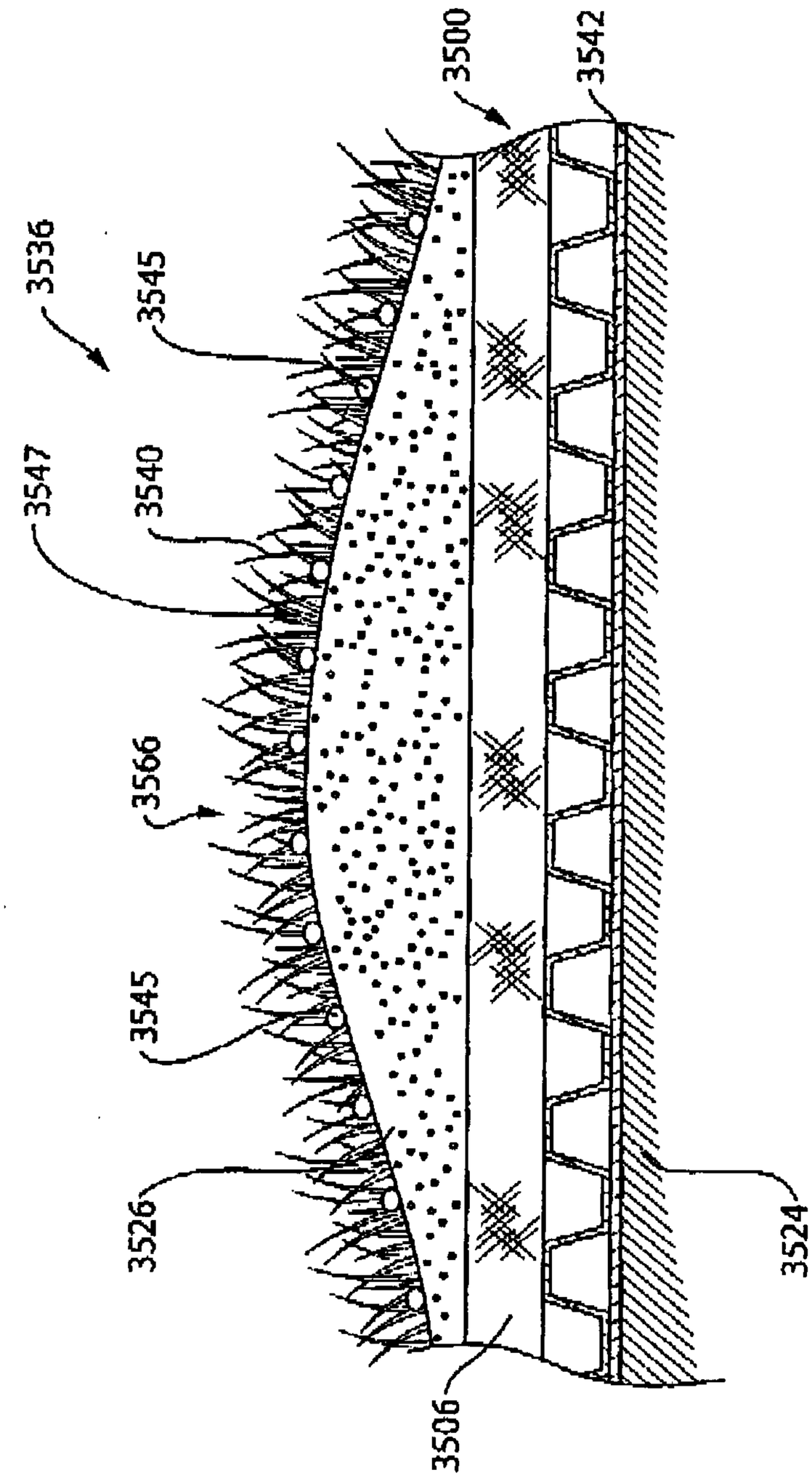


FIG.35

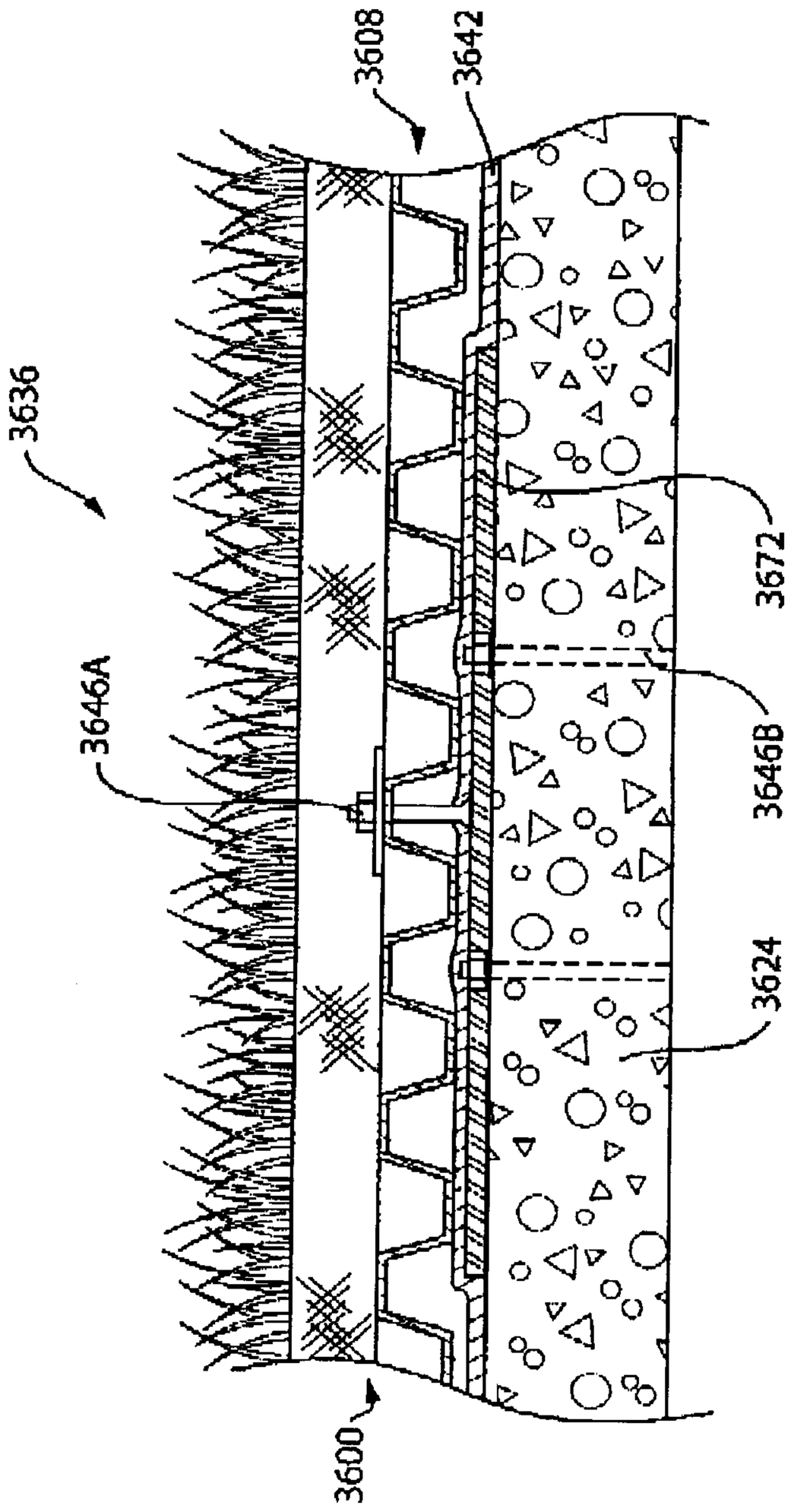


FIG.36

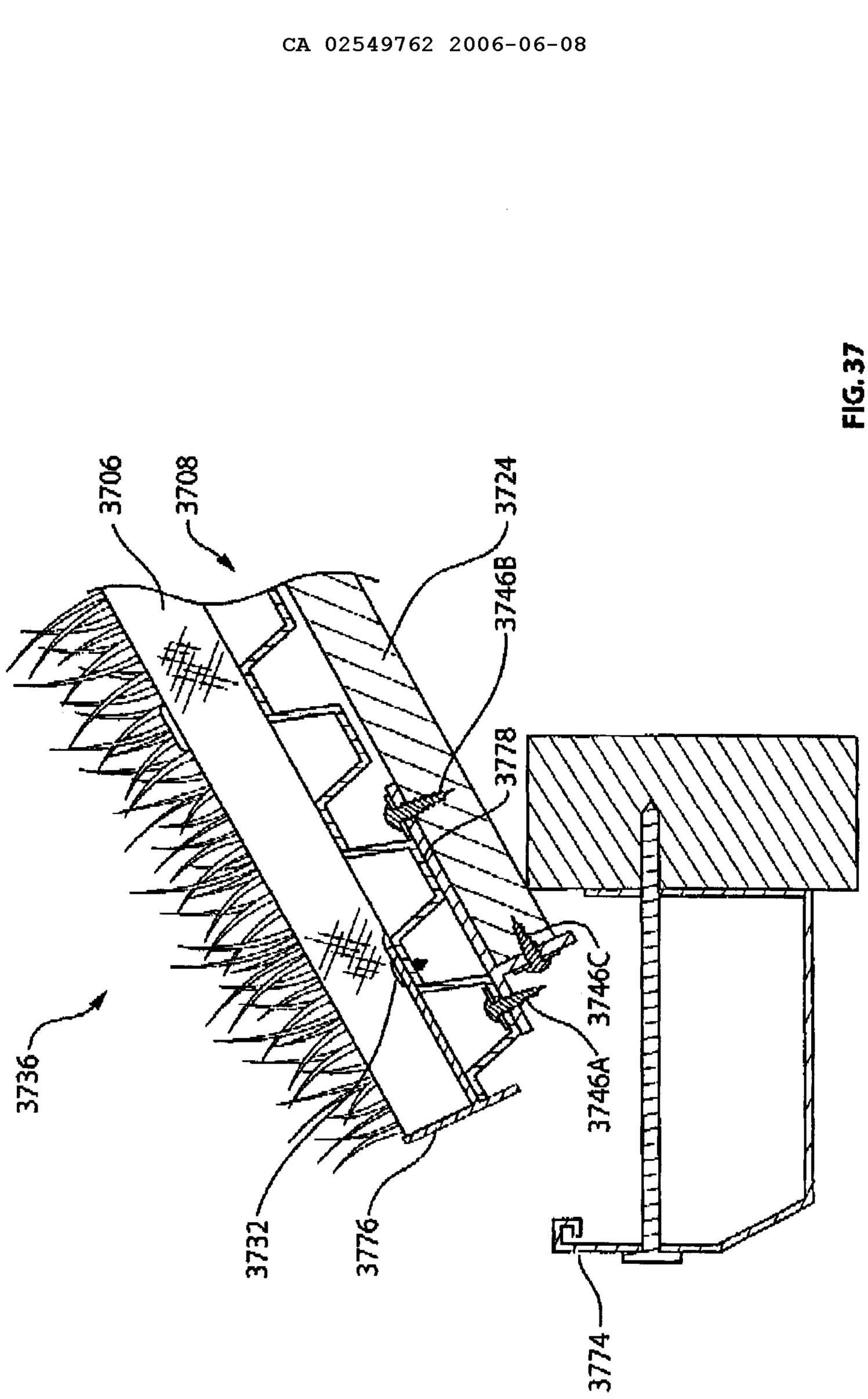
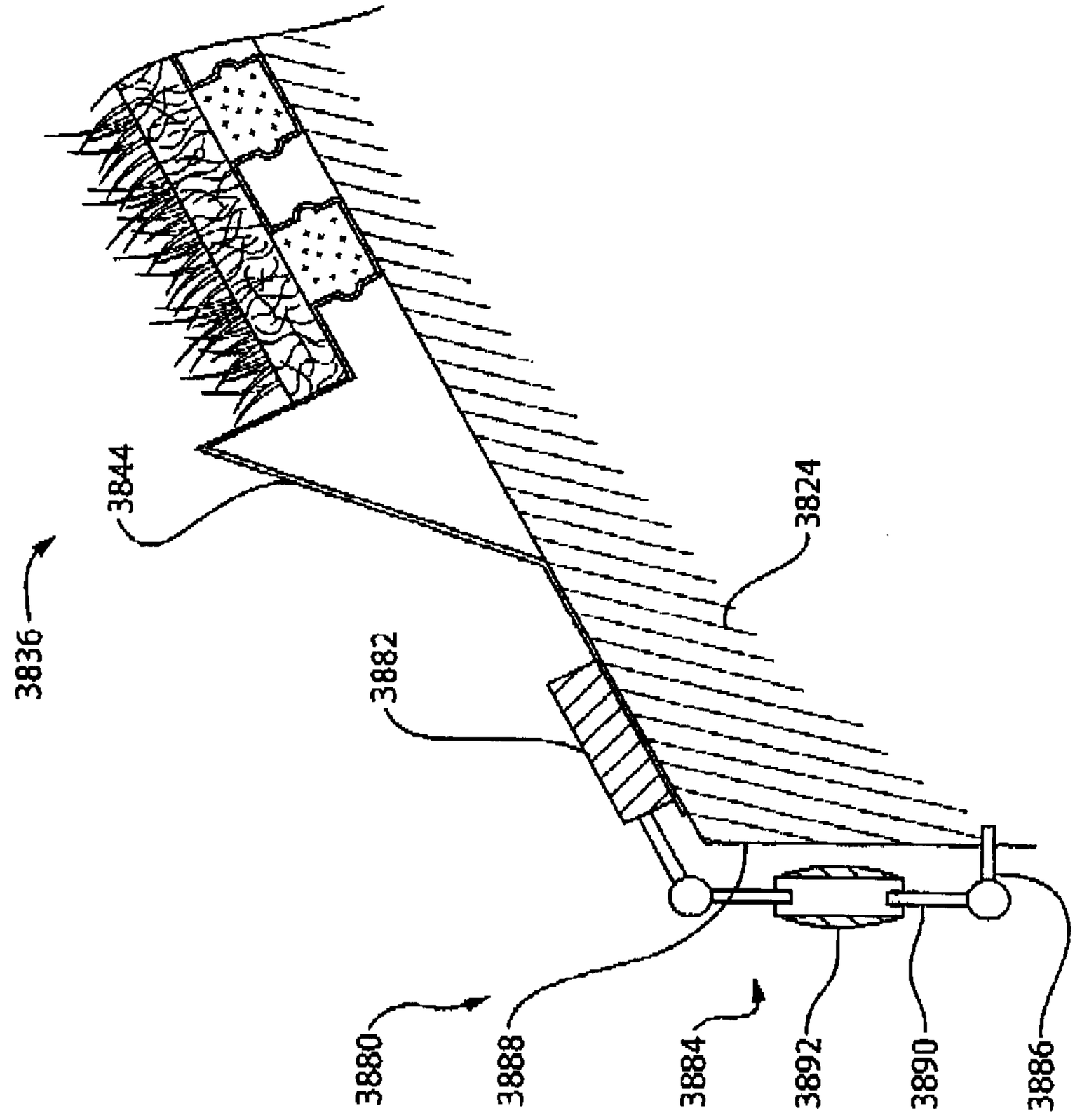


FIG. 37

FIG. 38



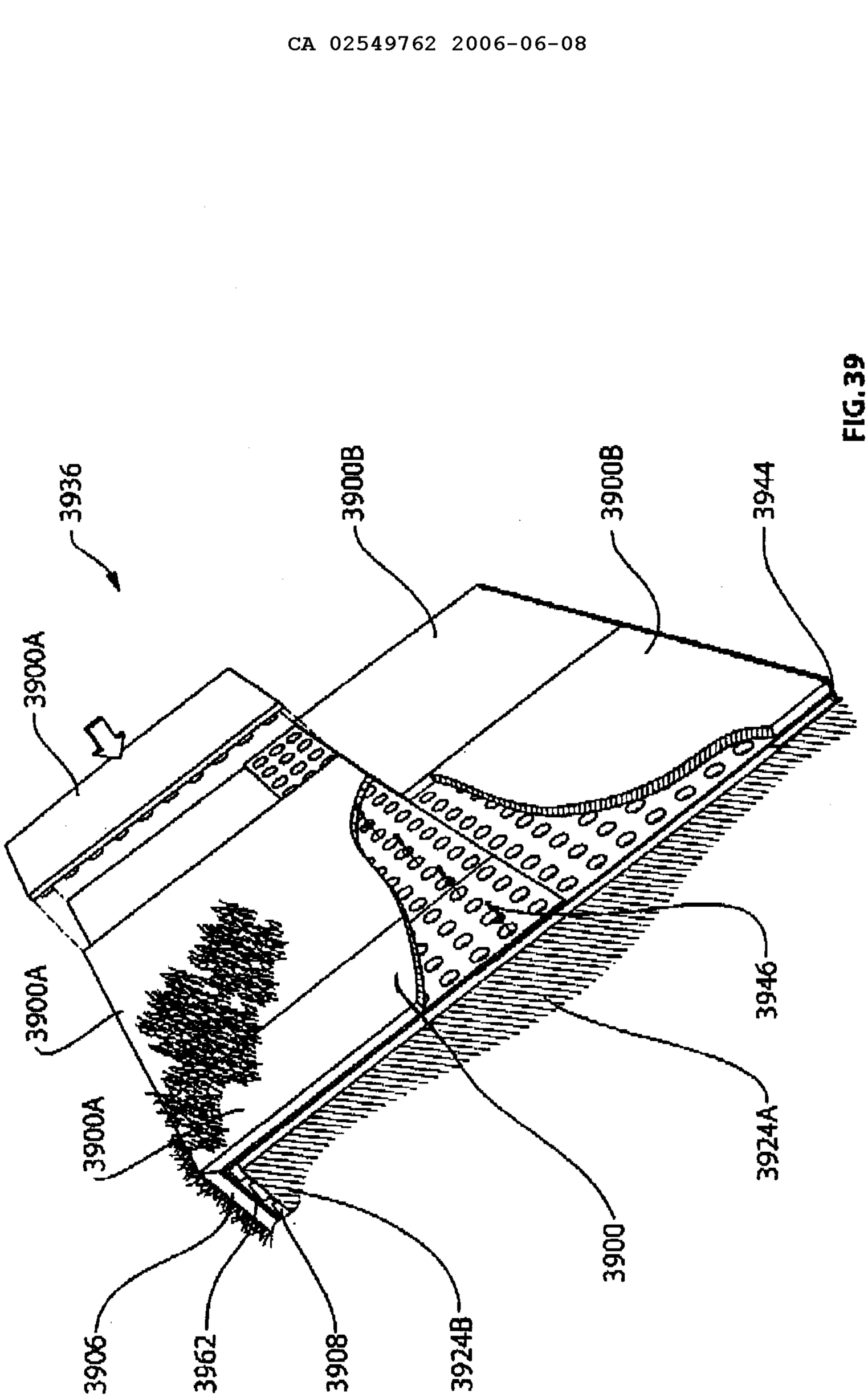

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FIG.39

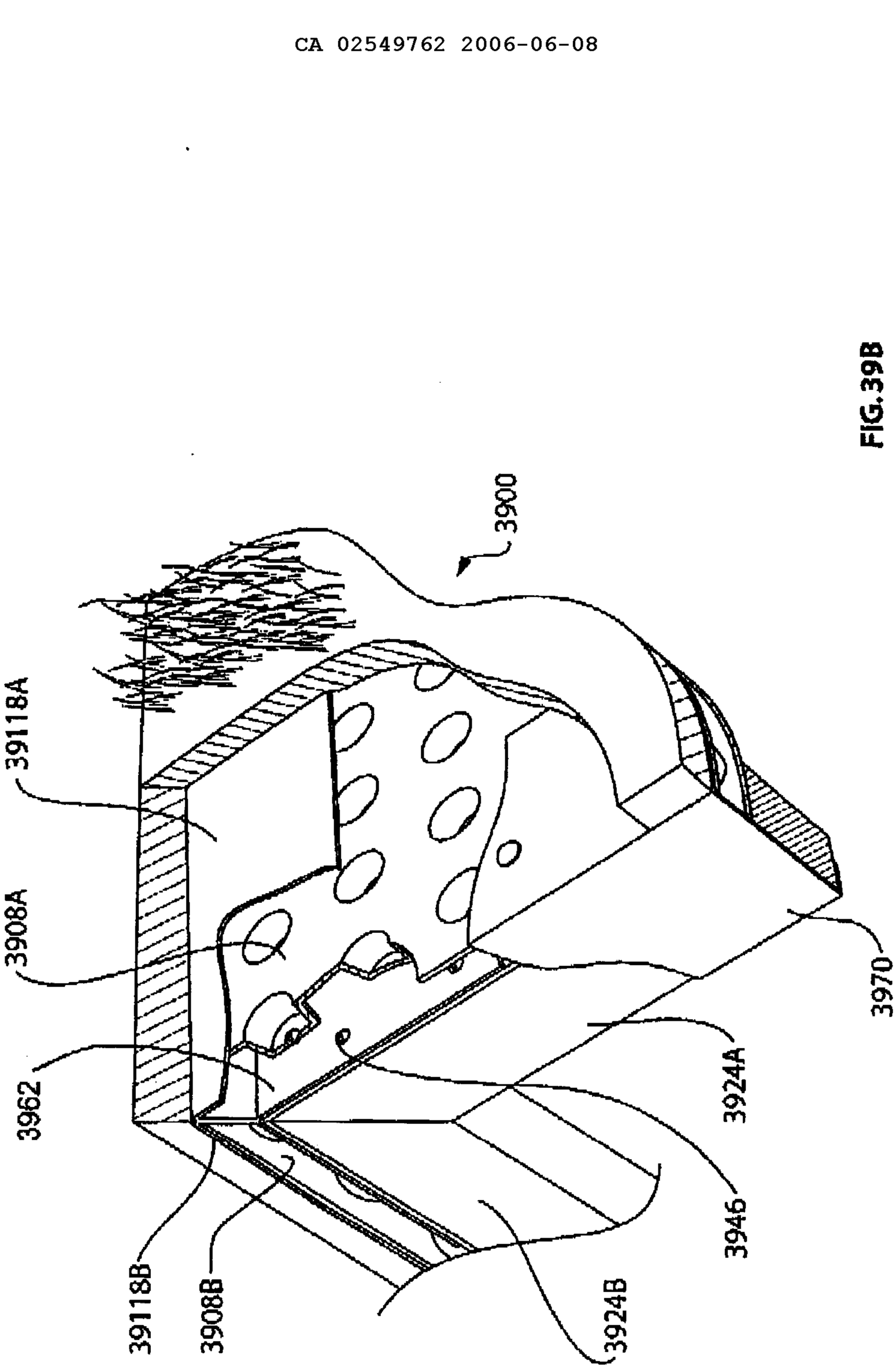

FIG.39B

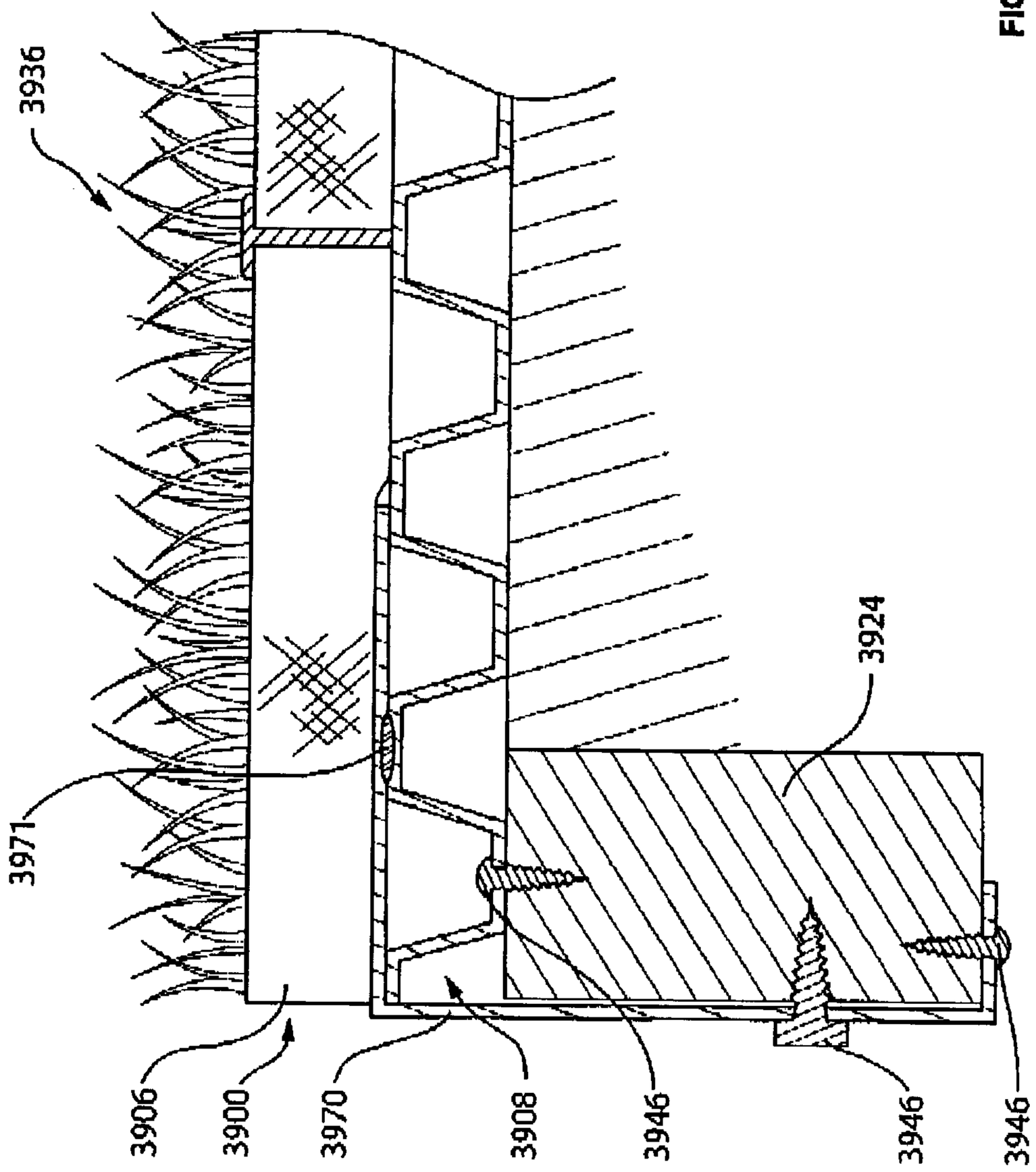

FIG. 39C

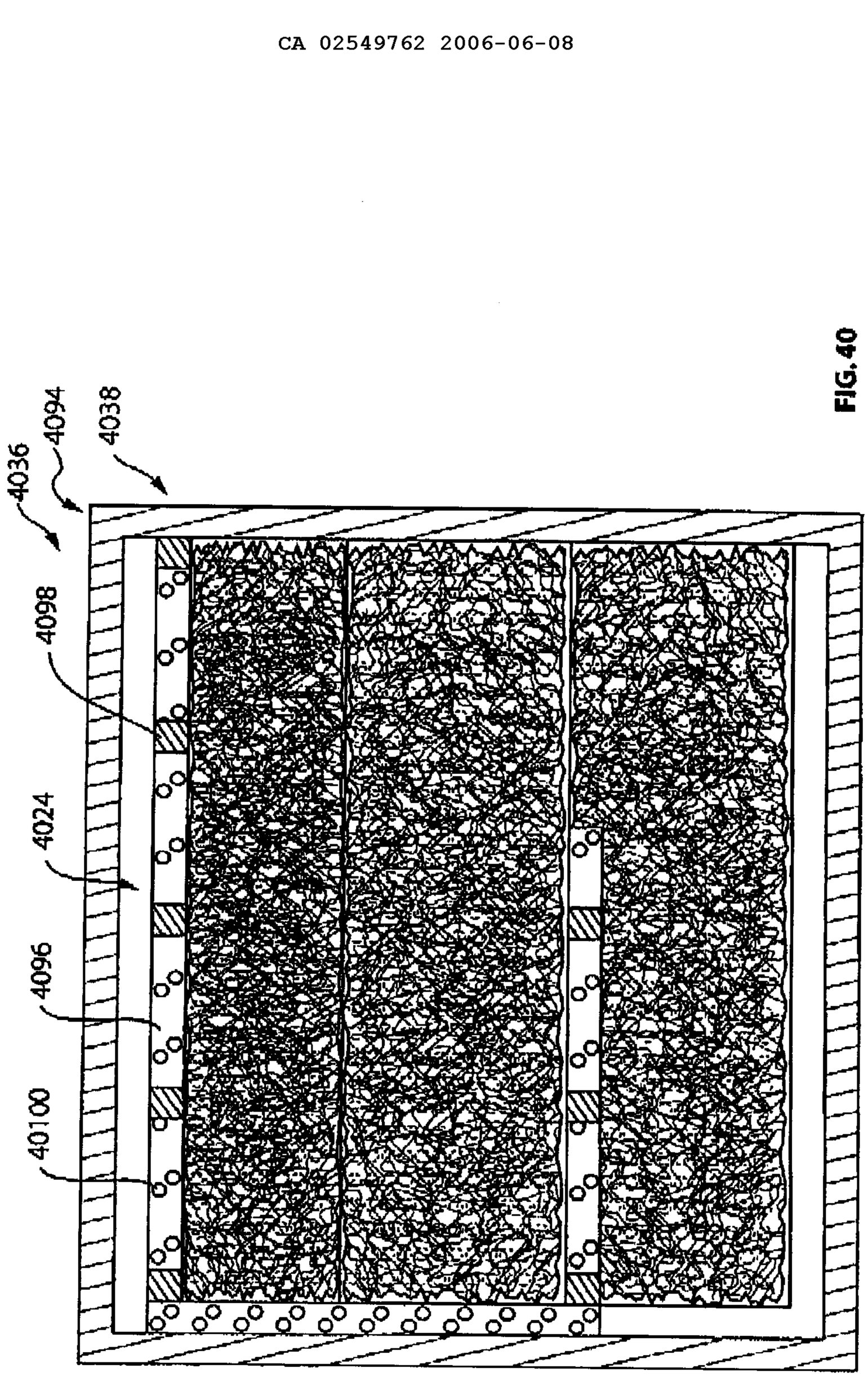

FIG. 40

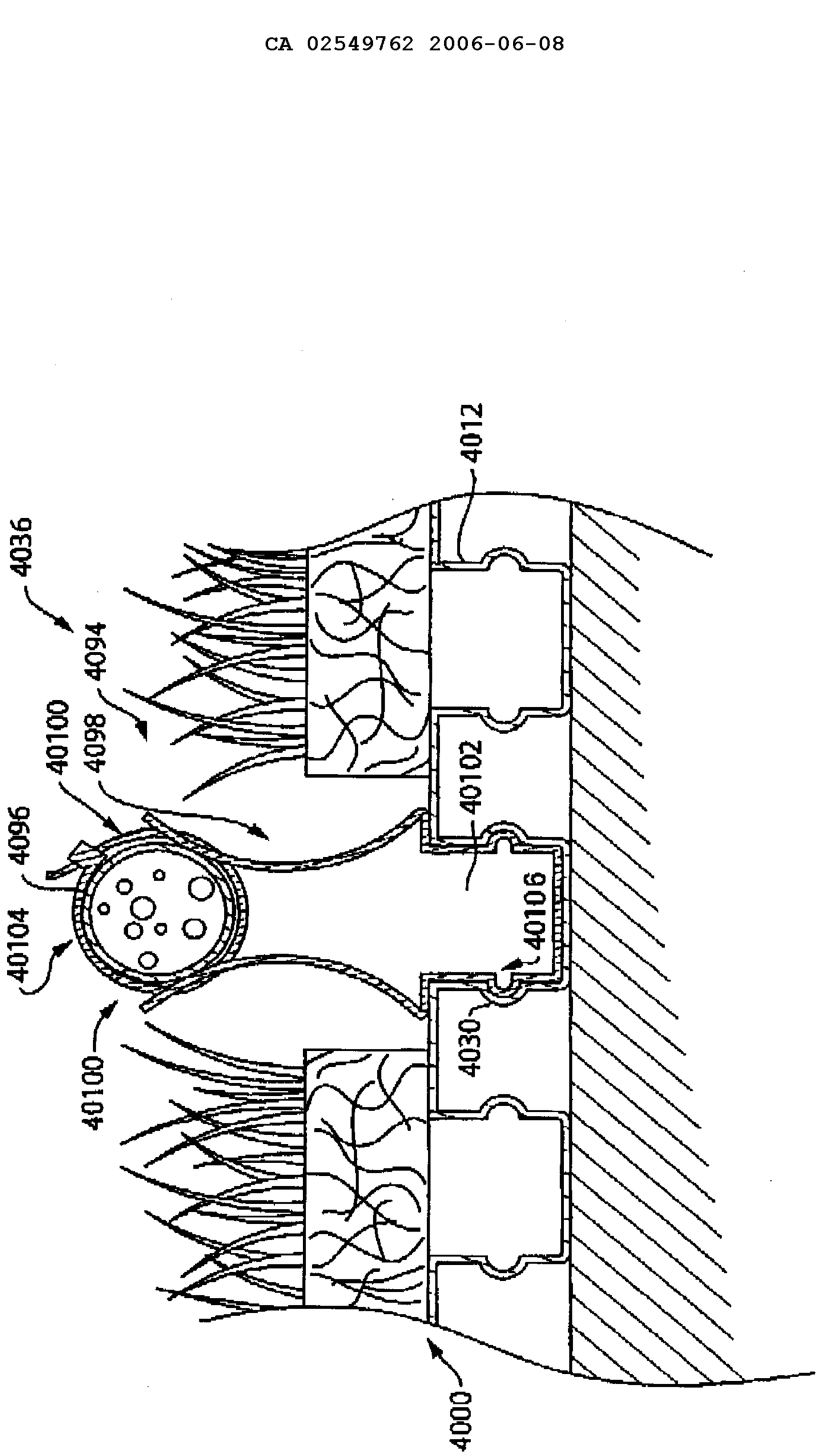
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FIG.41

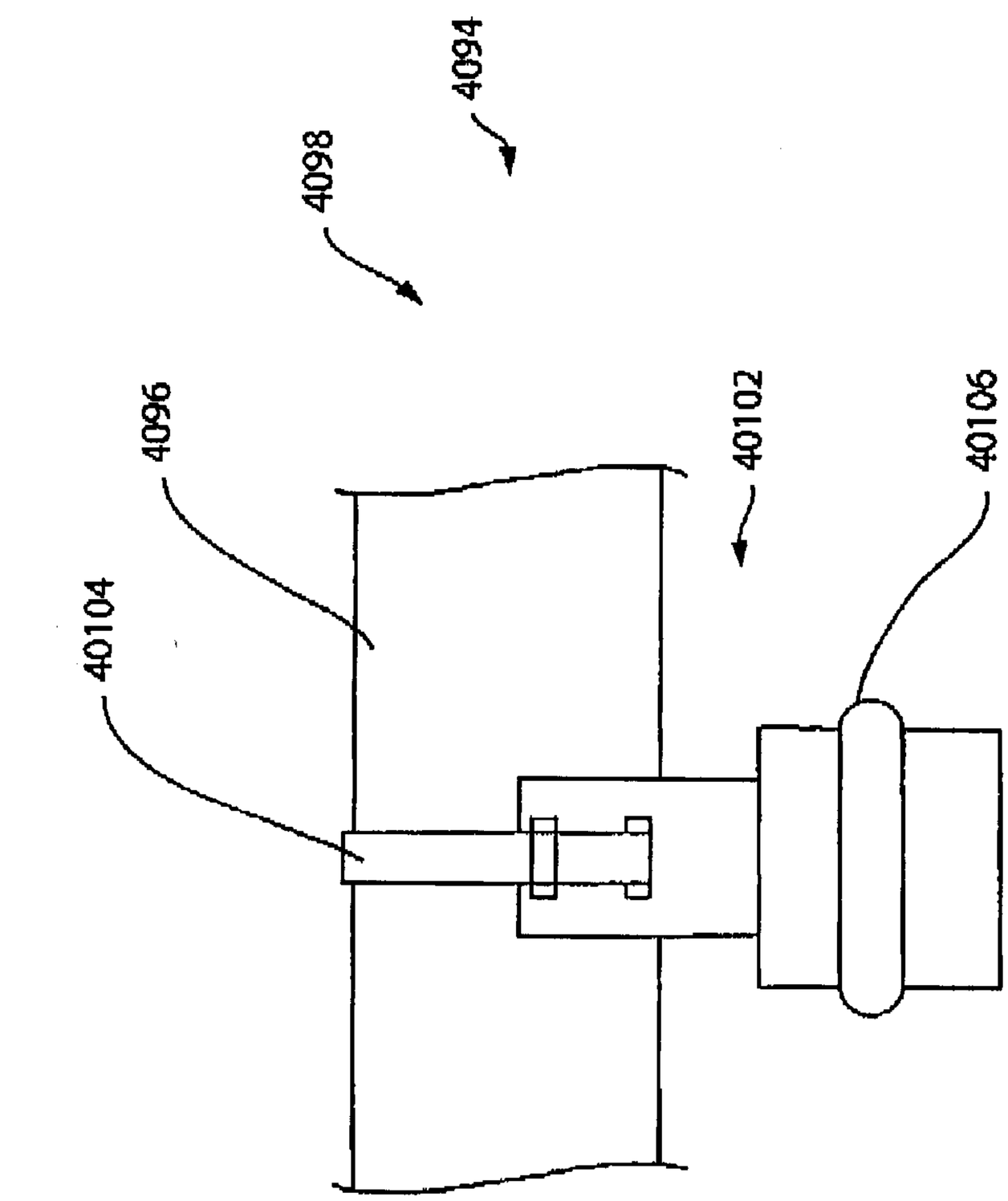


FIG.42

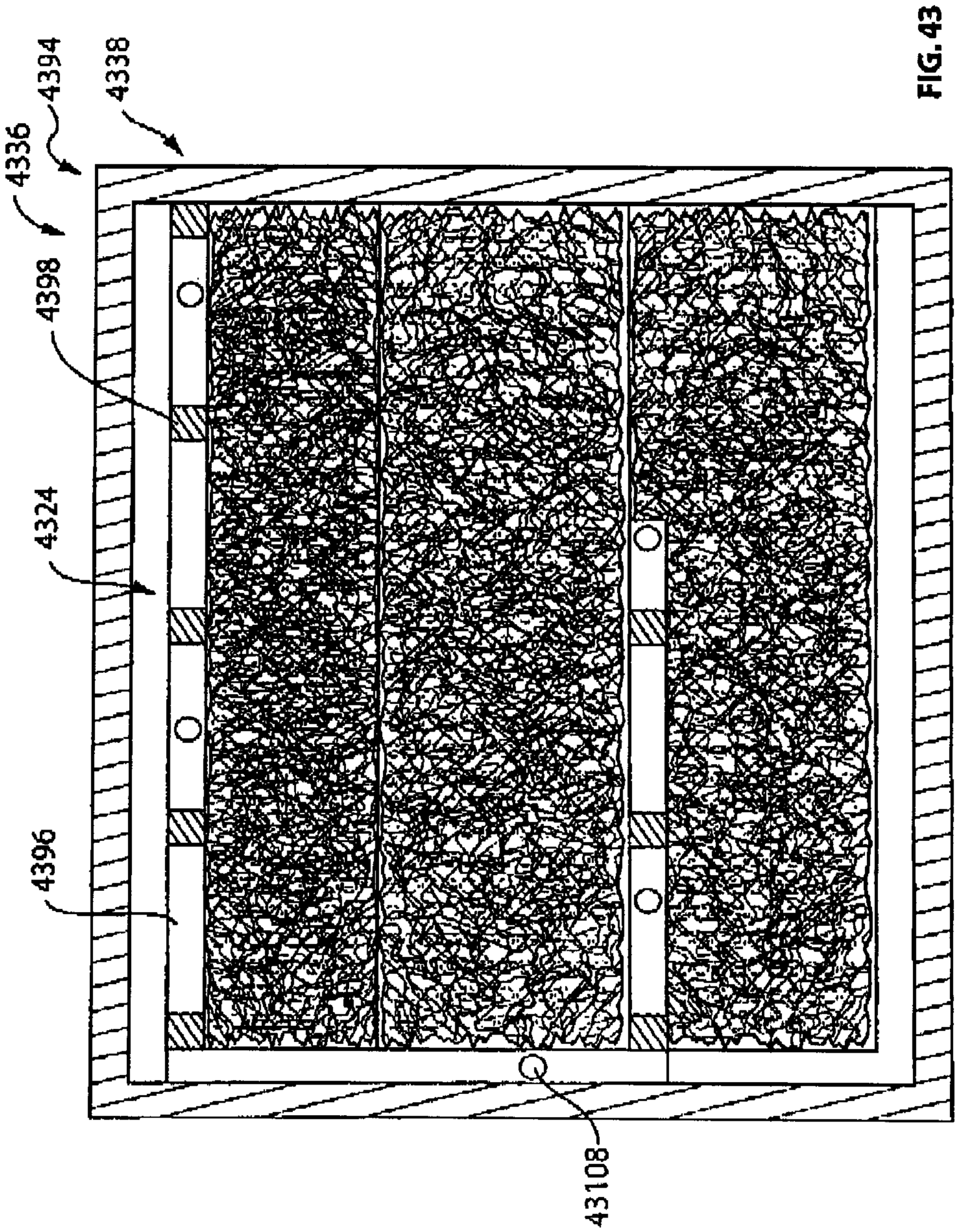


FIG.43

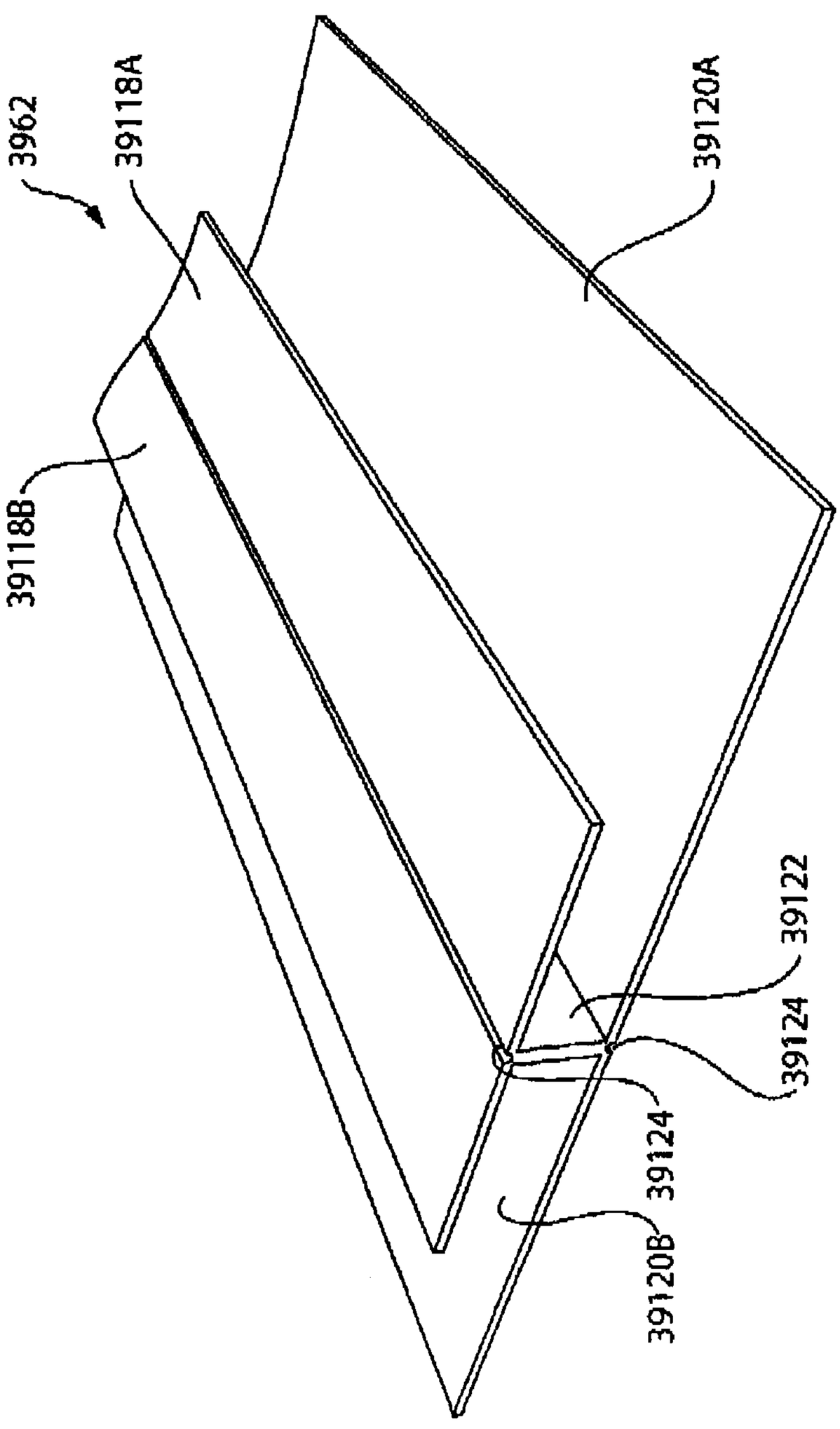


FIG. 44

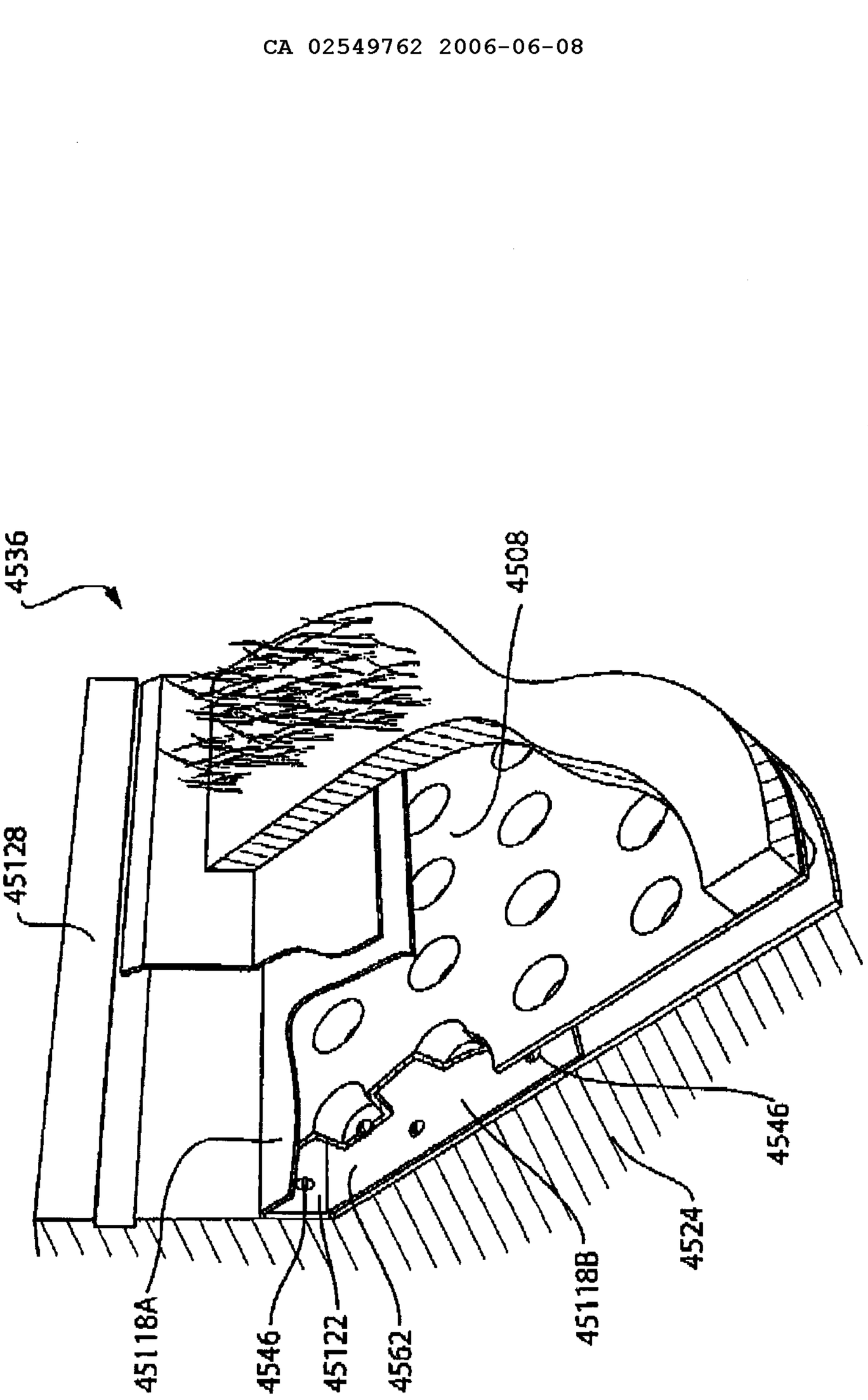


FIG.45

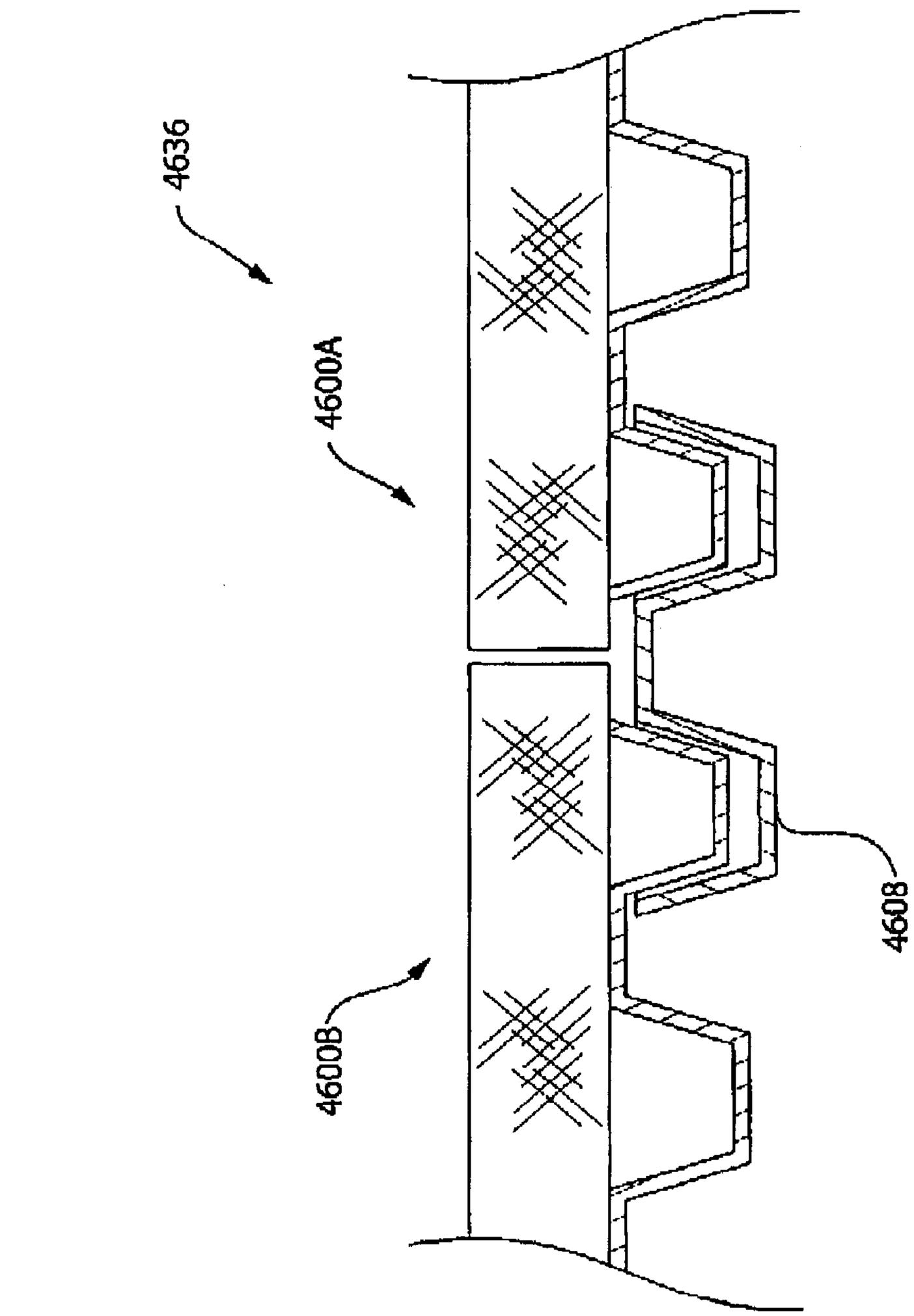


FIG. 46

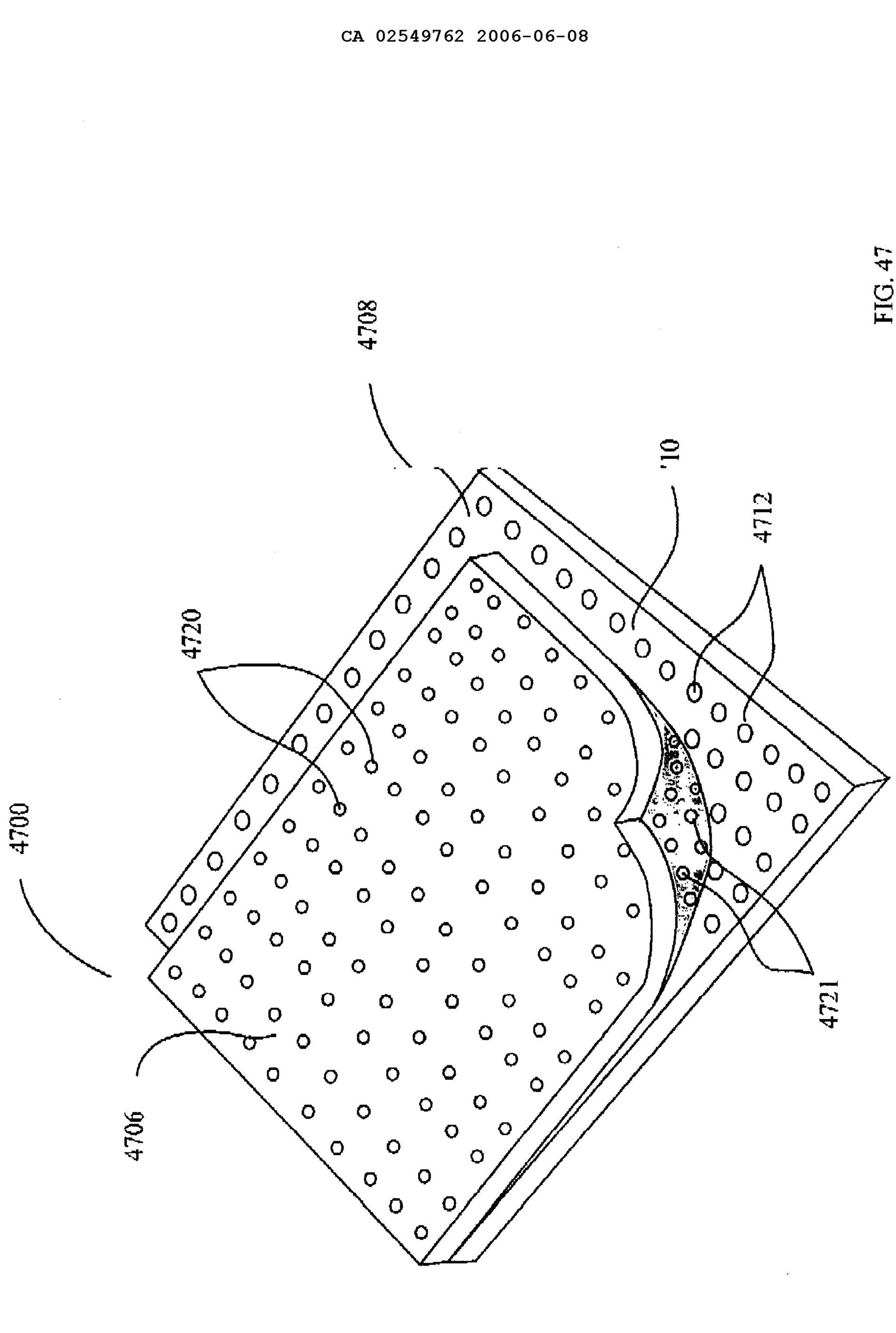


FIG. 47

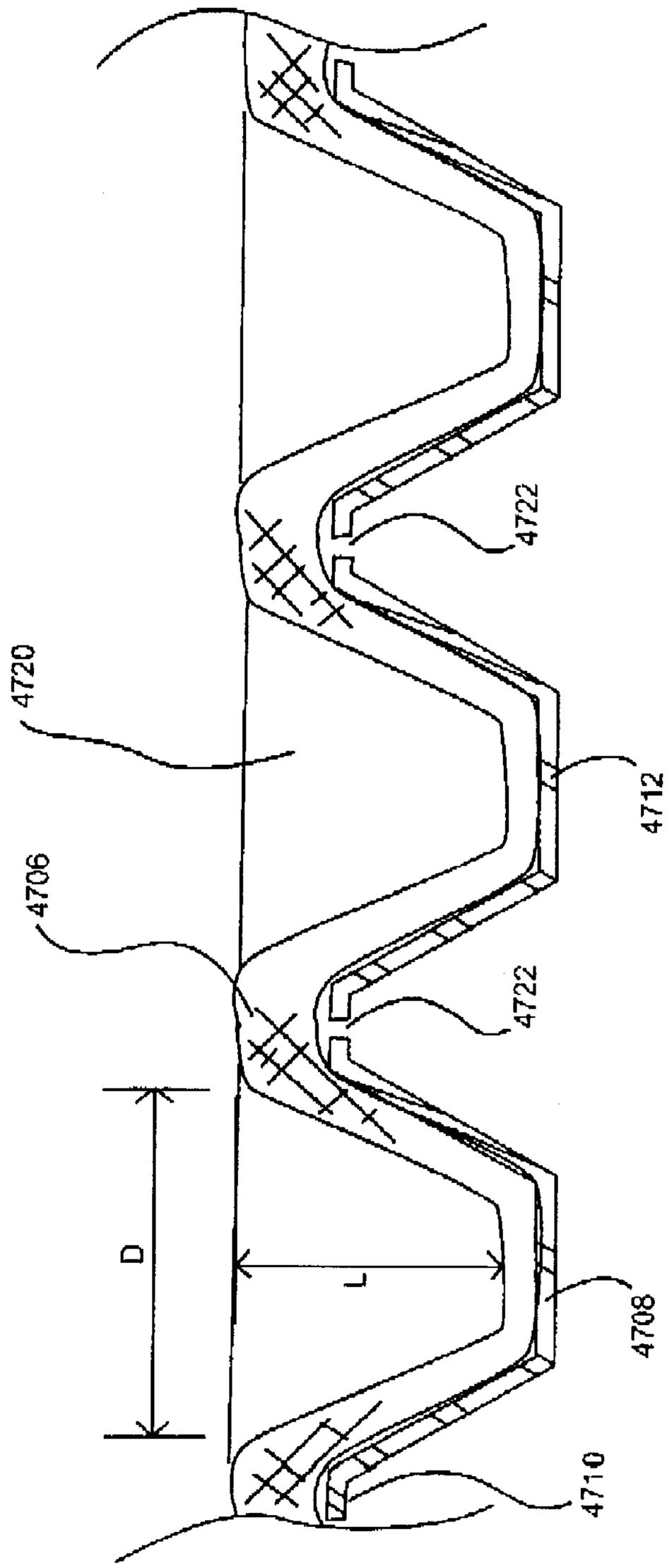


FIG. 48

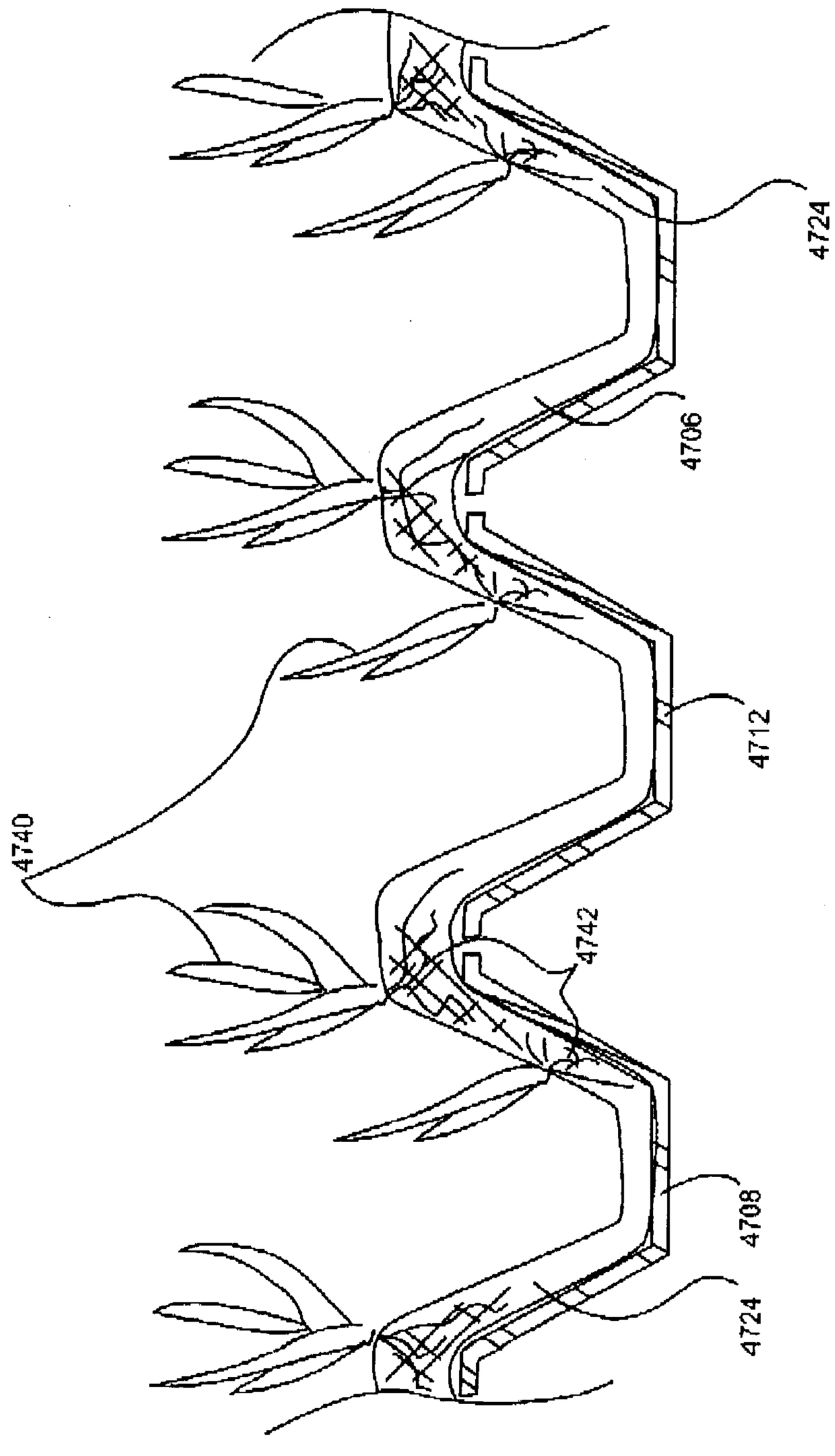


FIG. 49

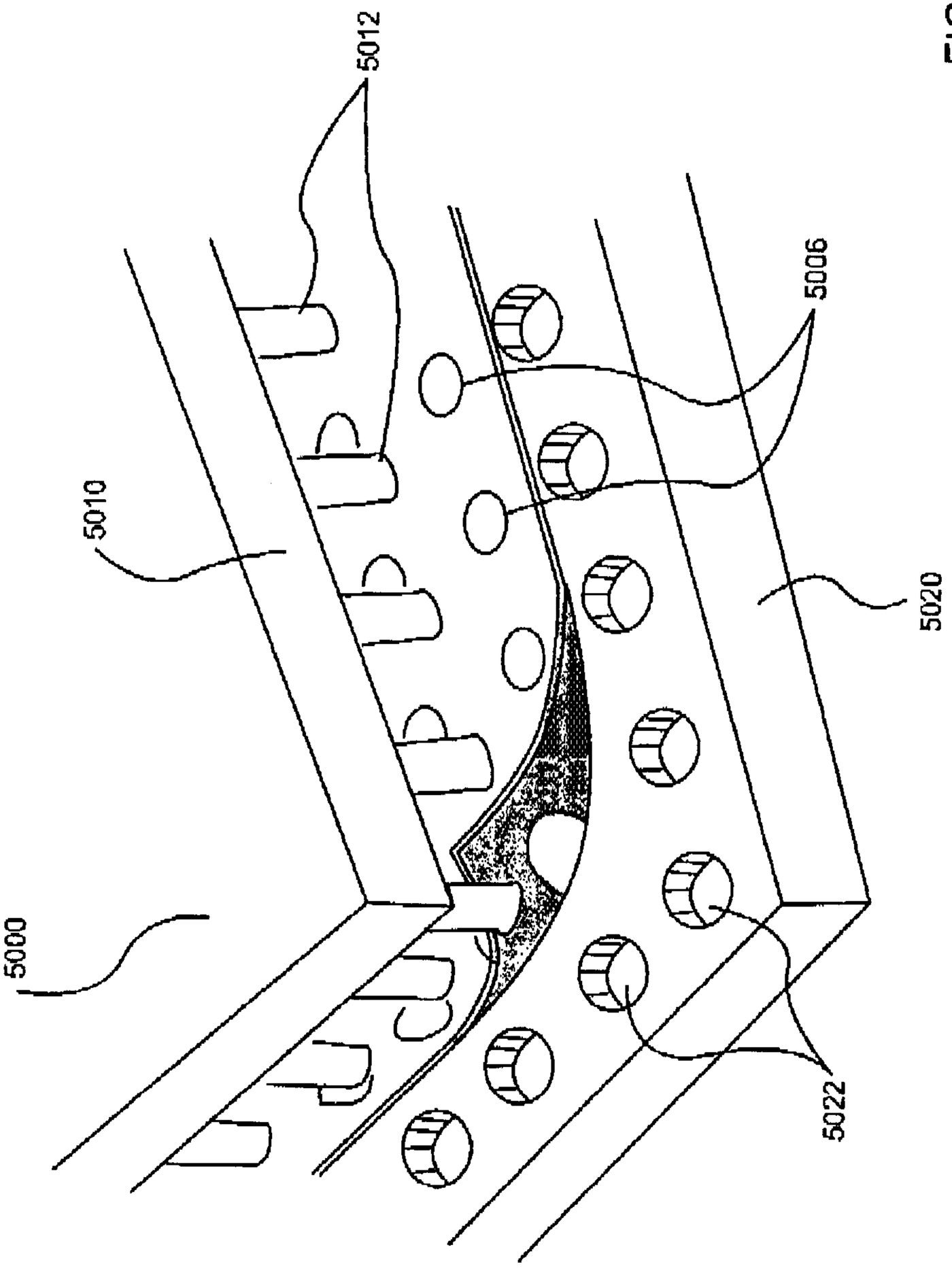


FIG. 50

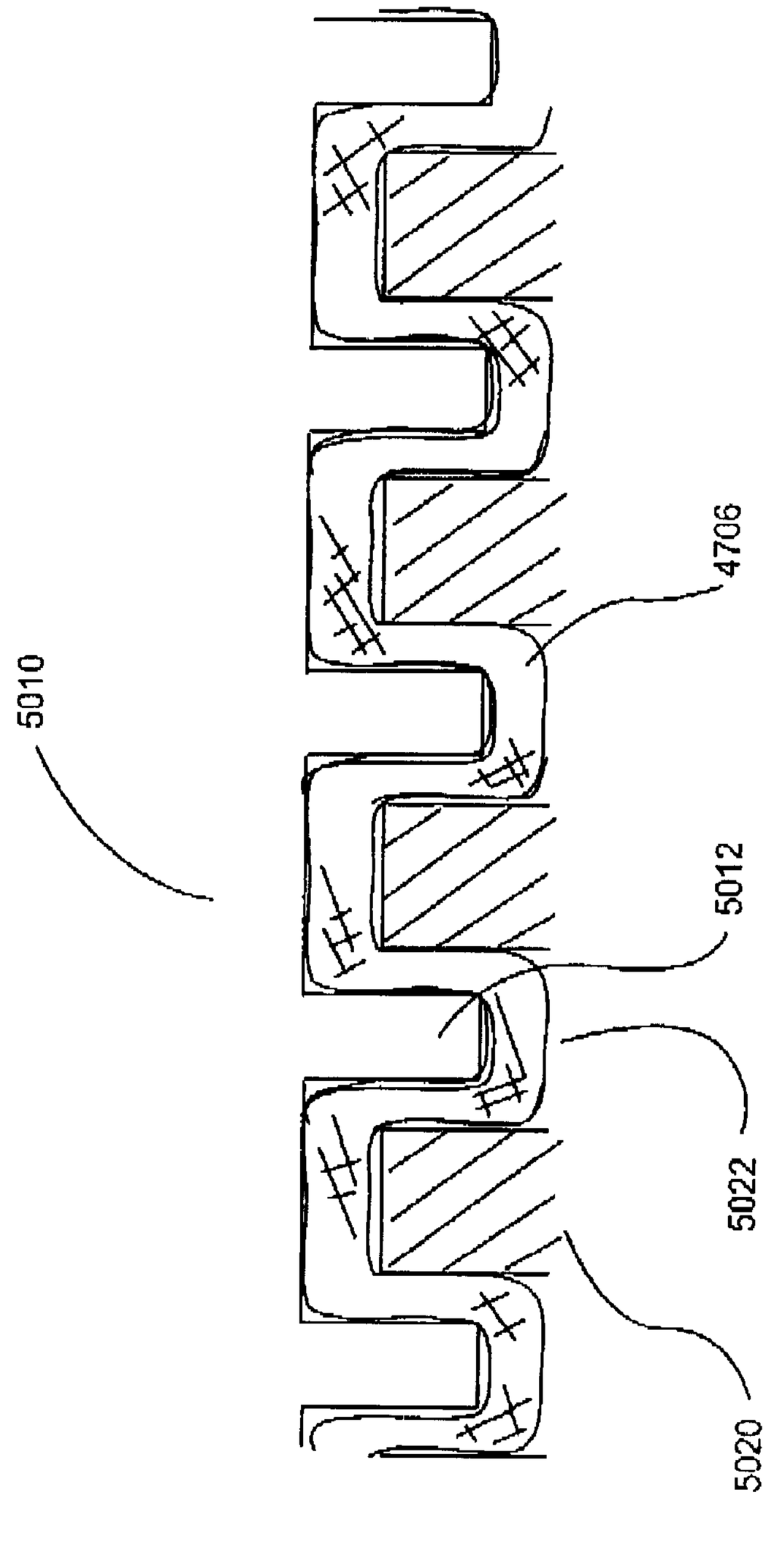


FIG. 51

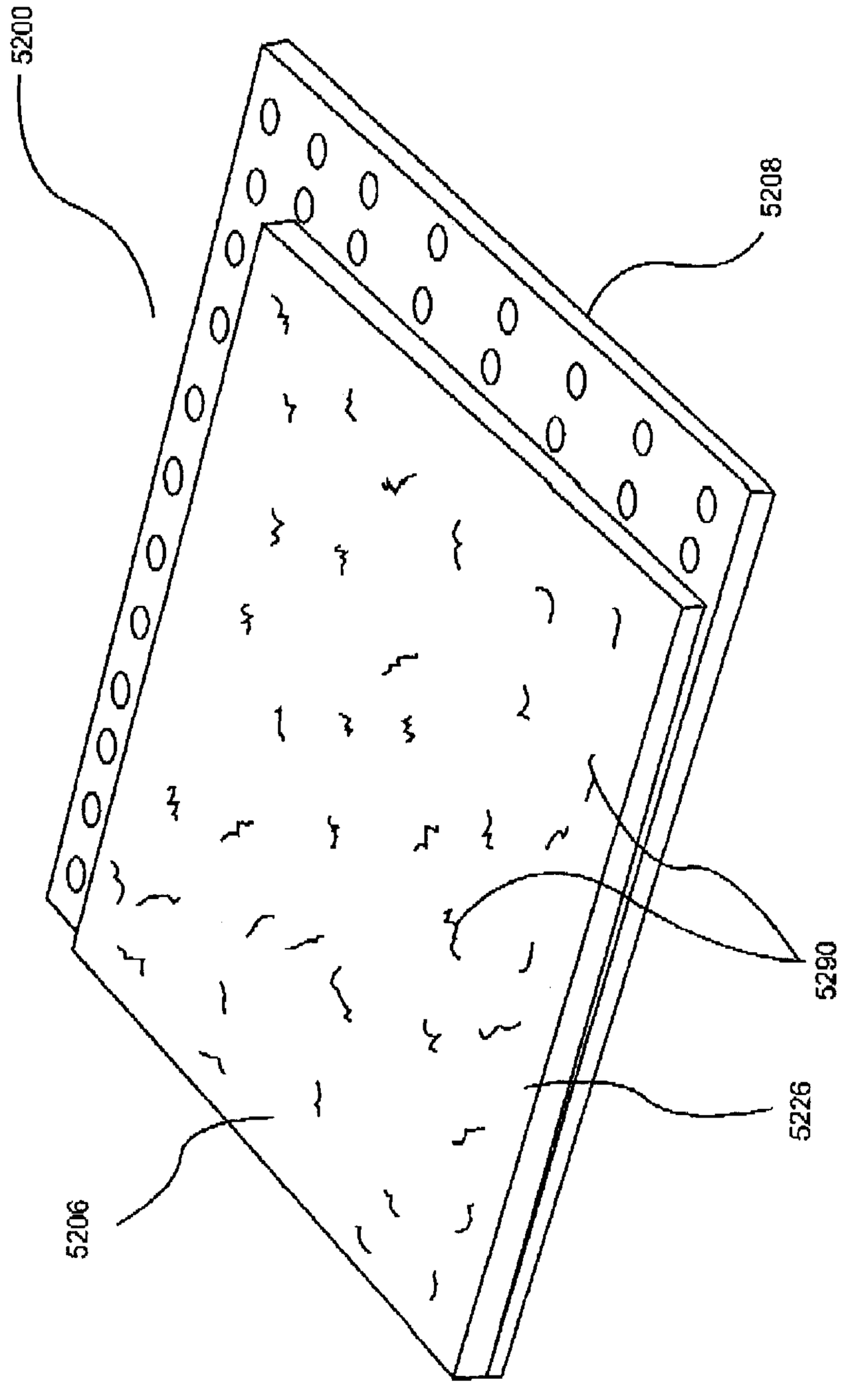
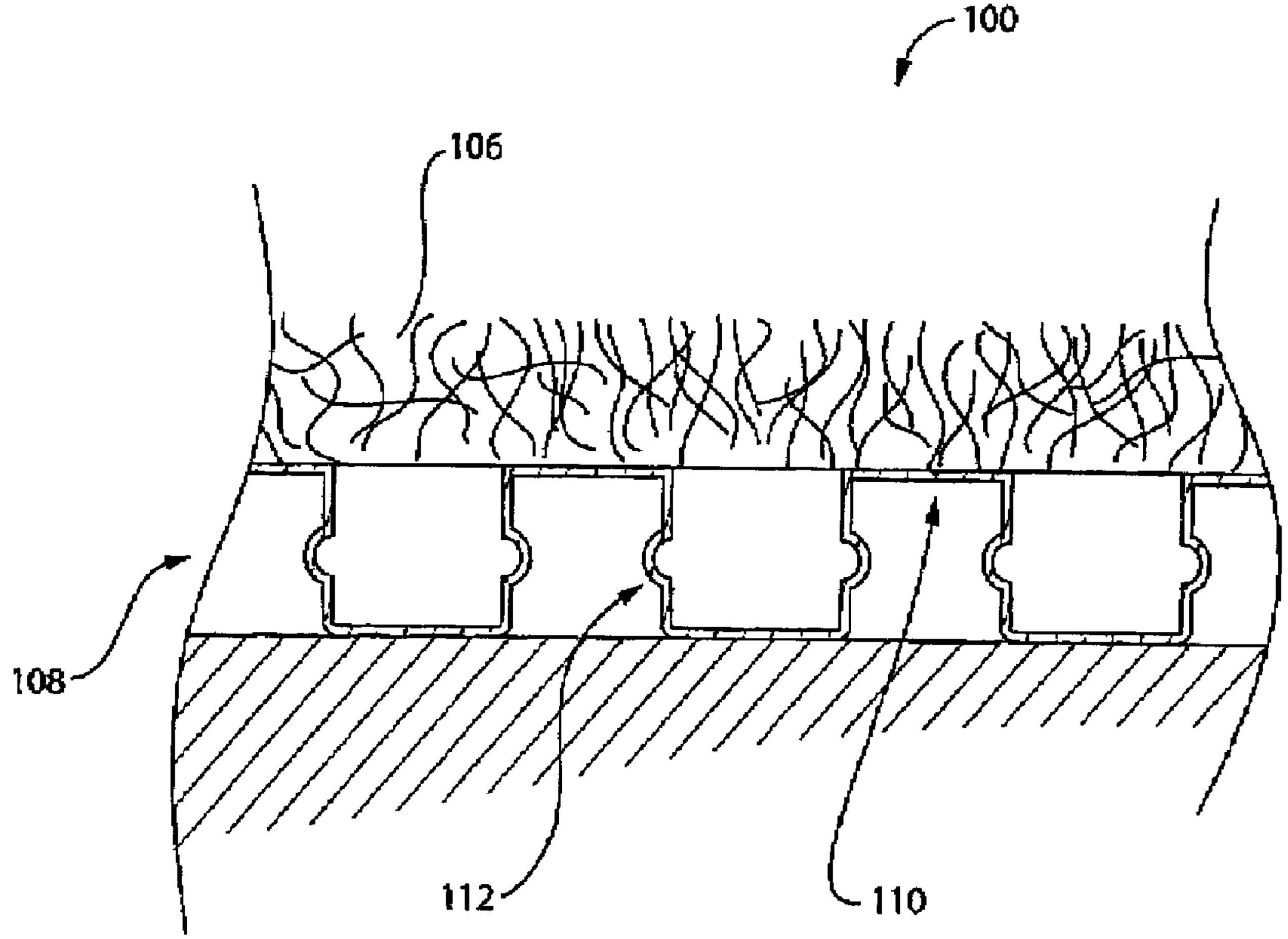


FIG. 52


100
106
108
112
110