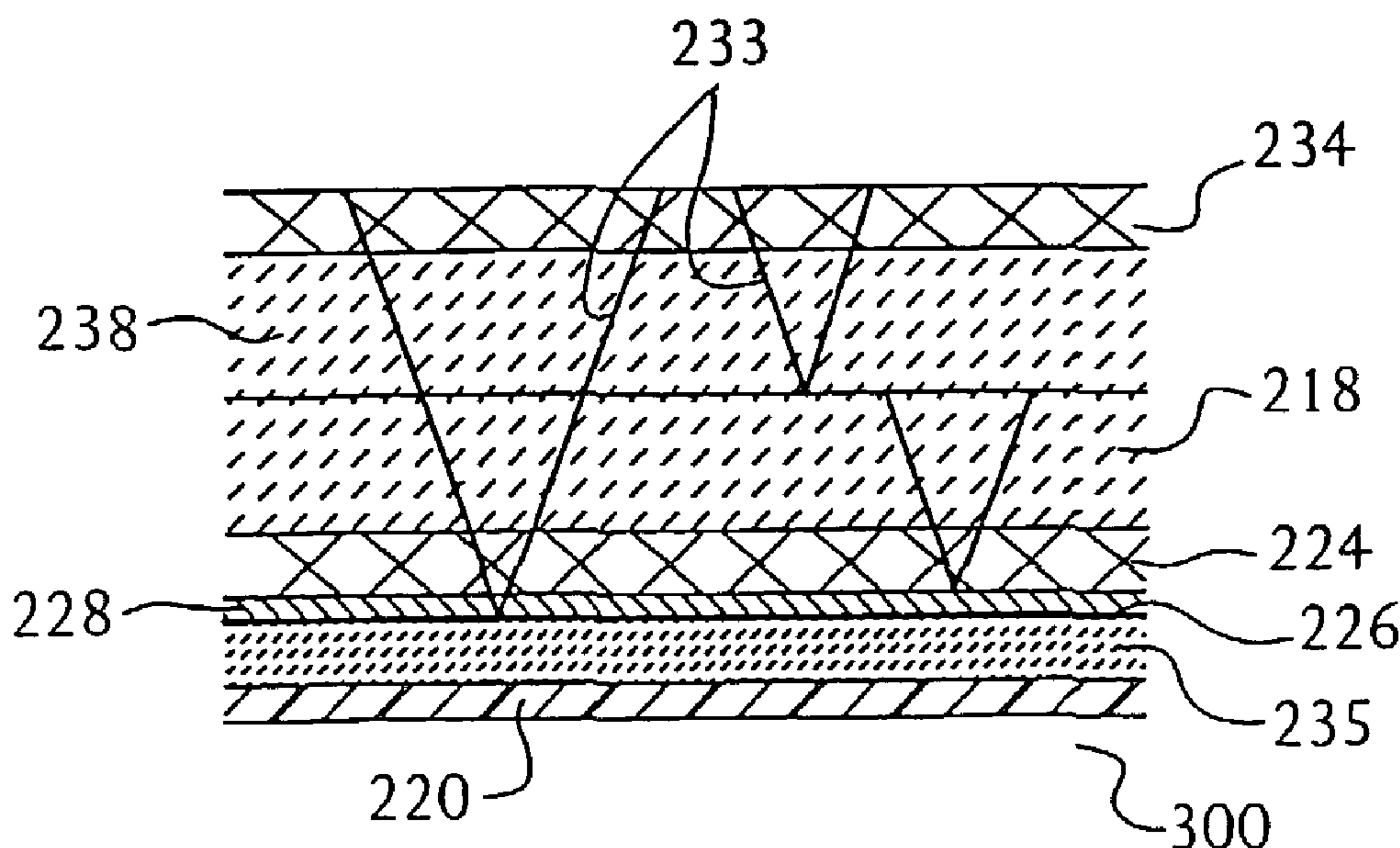




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 (54) Title: INVERSION LINER AND LINER COMPONENTS FOR CONDUITS



(57) Abrégé/Abstract:

Conduit liners (300) are provided which in a first embodiment include first and second flexible fabric layers (218, 238) joined to first and second high strength fiber containing layers (234, 224) and joined in tubular form, whereby the first and second flexible fabric layers face one another. One of the high strength fiber containing layers (234) or (224) further is joined to a substantially fluid impermeable layer, which can be directly bonded to one of said layers, or indirectly joined by way of a third flexible fabric layer. The disclosed method and liner construction can save one or more steps in the manufacture of glass-reinforced, polyester felt inversion liners.

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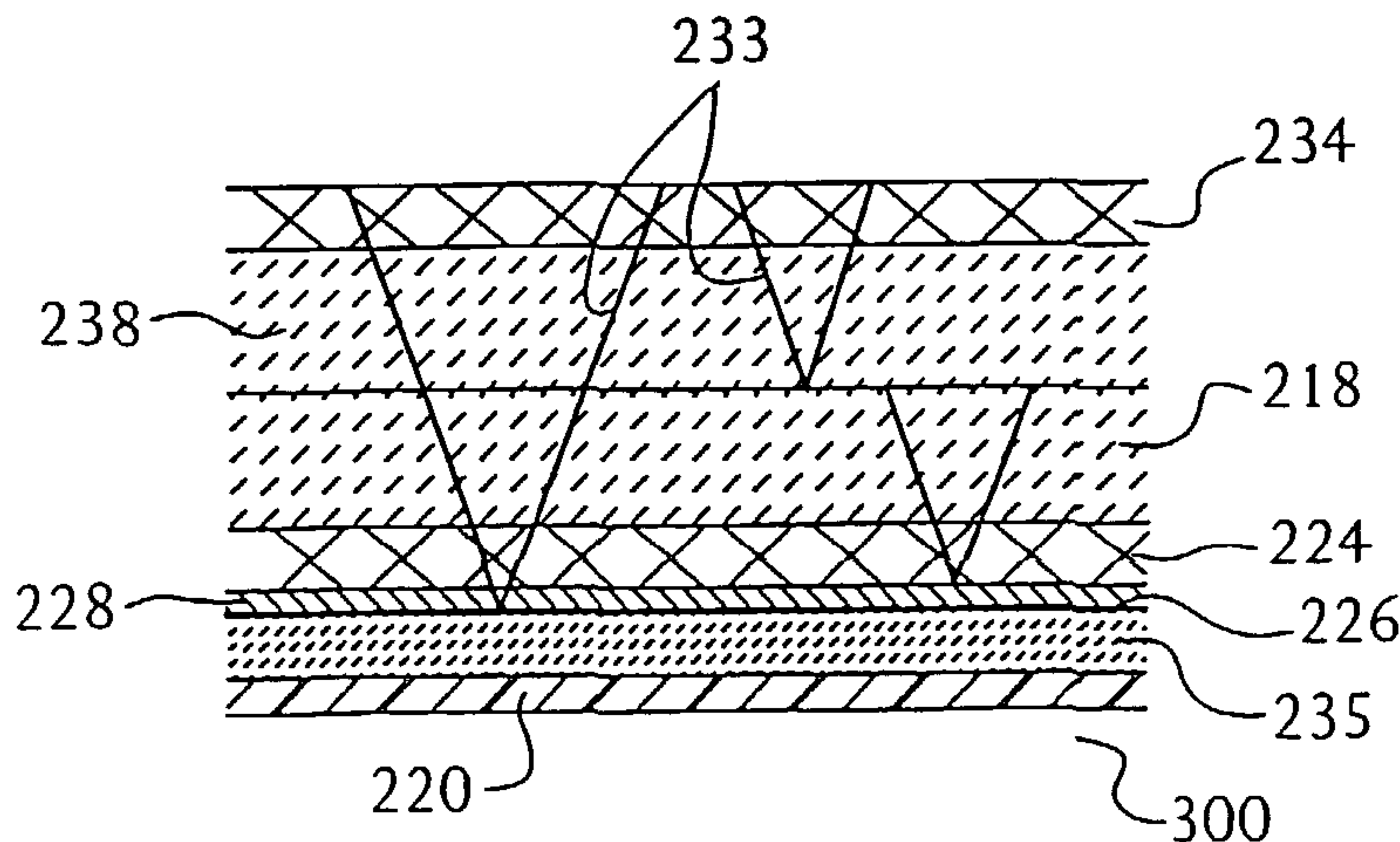
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(54) Title: INVERSION LINER AND LINER COMPONENTS FOR CONDUITS



(57) Abstract: Conduit liners (300) are provided which in a first embodiment include first and second flexible fabric layers (218, 238) joined to first and second high strength fiber containing layers (234, 224) and joined in tubular form, whereby the first and second flexible fabric layers face one another. One of the high strength fiber containing layers (234) or (224) further is joined to a substantially fluid impermeable layer, which can be directly bonded to one of said layers, or indirectly joined by way of a third flexible fabric layer. The disclosed method and liner construction can save one or more steps in the manufacture of glass-reinforced, polyester felt inversion liners.

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INVERSION LINER AND LINER COMPONENTS FOR CONDUITS

Related Application Data

[0001] This application is a continuation-in-part application of U.S. Patent Application No. 10/174,580, entitled "Inversion Liner and Liner Components for
5 Conduits" filed June 19, 2002, and is related to commonly assigned U. S Patent Nos. 5,836,357; 5,931,199; 5,911,246 and 5,873,391, which are all hereby incorporated by reference.

Field of the Invention

[0002] This invention relates to conduit liners for making repairs in underground
10 piping systems, and more particularly, to inversion liners that provide improved strength and greater inversion speed.

Background of the Invention

[0003] Underground piping systems are essential in providing the transportation of liquids and gases to homes and businesses. Used mostly by utilities in sewer pipes,
15 water pipes, water mains, gas mains, electrical conduits and other applications, such pipes are often found many feet under ground or in inaccessible areas, such as under buildings or roadways.

[0004] Due to cyclical loadings, premature wear, manufacturing defects, corrosion, and other factors, these pipes can often develop cracks or weakened areas
20 requiring repair. Since the replacement of underground pipes is extremely costly, an alternative is to provide a lining repair while leaving the remaining pipe structure in place. Various types of lining products have been commercialized in the past, some flexible, some rigid and some flexible when applied, but rendered rigid by a resin after application. In most cases, it is highly desirable to closely conform the lining to the inner
25 surface of the pipe. This has been generally accomplished by pressure - expandable techniques and inversion techniques.

[0005] In a “pressure - expandable” technique (also called the “winch-in-place” technique), a pliable polyester felt sleeve, which has been previously impregnated with a thermosetting resin is inserted into a damaged pipe portion and pressurized so that the resin-impregnated liner presses firmly against the inner wall of the damaged pipe. The expanded liner is then permitted to cure to form a new lining within the original pipe. More recently, pressure-expandable conduit liners have been introduced with glass reinforcement dispersed along the inner and outer surfaces of the liner. See Kittson, et al., U.S. 5,836,357, which is hereby incorporated by reference.

[0006] In the “inversion” technique, the pipe liner is first impregnated with a suitable curable synthetic resin. The resin-filled liner is next inserted into a pipe. The leading end of the liner is turned back onto itself and fixed to the lower end of a feed elbow of a manhole. A fluid, such as water or air, is pumped into the feed elbow which causes the liner to invert into and along the interior of the pipe. The liner is maintained in engagement with the pipe until the resin cures. After the resin cure has been completed, the fluid is drained from the inside of the liner, thus leaving a hard, rigid lining applied to the pipe’s inner surface.

[0007] Most inversion liners are formed of heavily needled felt of polyester or acrylic fibers. Needling causes the fibers to generally extend in right angles to the plane of the material.

[0008] Efforts to improve upon the mechanical properties of felt liners have included flowing chopped glass fibers onto the felt web prior to needling, Wood, U.S. Patent No. 4,390,574, or needling the felt with reinforcing fibers, such as carbon fibers, Kevlar® fibers or high tenacity polypropylene fibers, such as disclosed in Wood, U.S. Patent No. 4,836,715. Other techniques include the use of glass fiber cloth, mat or felt, or a non-woven felt of a mixture of synthetic and glass fibers, such as disclosed in Kamiyamma, et al., U.S. Patent No. 6,018,914.

[0009] The introduction of glass or other high strength fibers in needling operations, while increasing the average tensile strength of the fibers themselves, still

presents a less than desirable orientation, since the needled reinforcing fibers are also generally disposed at right angles to the plane of the material.

[0010] Kittson, et al., U.S. 5,836,357, shown in FIG. 2, teaches the use of glass roving in conjunction with chopped glass fibers for improving the tensile strength in at least the longitudinal direction of the liner. The Kittson et al. liner is “glass-faced”, being formed by a pair of glass fiber layers 2 and 3 stitched with a thread to a pair of felt layers 4 and 5, and sewn together in a tubular form. While this dramatically improves the liner’s mechanical properties, this liner has not been recommended for inversion techniques, and was designed for winch-in-place applications. The Kittson, et al. liner is also difficult to “build”, as in the subsequent building-up of additional liner layers or “blocks” due to the fact that glass layers are not “heat bondable” through conventional means. In addition, a separate impermeable foil or film must be added to contain pressure for expansion of this liner by heated fluids. Moreover, artisans have generally regarded building up layers of liners within an underground pipe to be impractical.

[0011] Accordingly, there remains a need for an inversion liner that can optionally be built up, such as by heat bonding or by adhesive bonding, for example, with several liner layers for large diameter pipe and manhole applications. There further remains a need for a reinforced inversion liner material, suitable for small and large conduits alike, which can be made thicker by layering a number of simple building blocks, preferably without significantly affecting the overall modulus of the liner.

Summary of the Invention

[0012] In a first embodiment, the present invention provides a method for making a tubular inversion liner, or liner block. This method includes the steps of providing first and second flexible fabric layers fastened to first and second glass fiber containing layers, respectively, followed by combining the first and second flexible fabric layers and the first and second glass fiber containing layers so that the first and second flexible fabric layers are sandwiched between the first and second glass fiber containing layers. The method further includes the step of joining a third flexible fabric layer, which is much

thinner than the first and second flexible fabric layers, to the first or second glass fiber containing layer. Finally, a substantially fluid impermeable layer is applied to the third flexible fabric layer such that the impermeable layer becomes the outermost layer of the liner, or liner block prior to inversion.

5 [0013] The present invention provides a more efficient construction method than those previously provided in the inversion liner field. By stitching, gluing or heat bonding a thin veil, having a thickness of about .1-1.0 mm, to the second glass containing layer, and applying an integral fluid impermeable layer on the veil, a tubular inversion
10 liner can be manufactured with a reduced number of layers, which makes the inversion liner easier to invert, lighter to carry and cheaper to manufacture.

 [0014] In a further embodiment of this invention, a method of manufacturing a tubular inversion liner, or liner block, is provided which includes the steps of providing first and second flexible nonwoven polyester fabric layers, each of which is fastened to a glass fiber containing layer. The method further includes stitching, or otherwise
15 attaching, a nonwoven polyester veil, together with the first and second flexible nonwoven polyester fabric layers and the first and second glass fiber containing layers, whereby the veil is attached to the second glass fiber containing layer, followed by joining a substantially fluid impermeable layer to the nonwoven polyester veil. The substantially fluid impermeable layer then becomes the outermost layer of the liner, or
20 liner block, prior to inversion, and becomes the innermost layer after inversion.

Brief Description of the Drawings

[0015] The accompanying drawings illustrate preferred embodiments of the invention according to the practical application of the principles thereof and in which:

[0016] FIG. 1: is a diagrammatic cross-sectional view illustrating a preferred
25 double-block inversion liner of this invention disposed within a pipe;

[0017] FIG. 2: is an enlarged cross-sectional view of a segment of a typical prior art lining having a glass-faced construction;

[0018] FIG. 3: is an enlarged cross-sectional view of a segment of a preferred liner of this invention;

[0019] FIG. 4: is an enlarged cross-sectional view of a segment of a composite double-block liner, including the liner of FIG. 3;

5 [0020] FIG. 5: is an enlarged cross-sectional view of a segment of an improved glass-faced liner of this invention;

[0021] FIG. 6: is an enlarged cross-sectional view of a segment of a composite triple-block liner, including the double-block liner of FIG. 4; and

[0022] FIG. 7: is an enlarged cross sectional view of a segment of a liner or liner
10 block having a thin veil coated with a liquid impermeable layer.

Detailed Description of the Preferred Embodiment

[0023] The present invention is related to inversion liners of the type that can be inverted with the assistance of fluid pressure, such as compressed air, steam or hot water
15 (hereinafter "fluids") to expand within a defective conduit and generally, mechanically mate or bond within, or come in close proximity to, the inner diameter of the conduit prior to curing to form a substantially corrosion and water resistant sleeve. As such, the liners of this invention are thin, tubular members which can exhibit a tubular, tape-like or ribbon-like cross-section prior to inversion. As used herein, the term "buildable" refers to
20 the ability of the liners of this invention to be adhesively bonded to a second or subsequent liner block to build up the thickness of the liner to its final thickness, and the term "glass-faced" means a liner having at least one glass layer located on, or proximate to, its face or faces. Building techniques for liner materials are often useful for large pipes of 36-40 inches or greater in diameter, in which liner building blocks of about 4-14
25 mm are added together to build up to a thickness of about 12-50 mm in final thickness, for example. This building can be done whenever the tube is assembled, by the

manufacturer or installer, for example, preferably before inversion or installation. Alternatively, the liners of this invention can be made with thicker layers or more layers of fabric disposed between two glass-containing layers, which in turn can be made thicker, to achieve final product thickness. The liners described herein provide high
5 flexural modulus and strength but are still vibration and corrosion resistant.

[0024] With reference to the drawings, and particularly FIGS. 1 through 7 thereof, there is shown preferred inversion liners 300, 500, and 600 or liner blocks 100, 200, 400 and 850. For example, liner block 100, shown in FIG. 3, contains first and second flexible fabric layers 18 and 28 which are adhesively, mechanically and/or heat bonded to
10 one or more glass fiber containing layers 24 and 34. This is most preferably accomplished, for example, by stitch thread 33 sewn to bond the fabric layer 18 to the glass fiber containing layer 24, and the flexible fabric layer 28 to the glass fiber-containing layer 34, followed by stitching all of these layers 28, 38, 24 and 18 together. The resulting liner block 100 includes one or more longitudinal seam portions, preferably
15 an outer seam portion and an inner seam portion which are preferably not radially aligned so as to avoid a continuous radial discontinuity through the wall thickness of liner block 100, as described in Kittson et al., U.S. Pat. No. 5,836,357.

[0025] In the preferred embodiment of FIG. 3, glass-faced needled felt is manufactured in blankets by disposing chopped glass and/or glass roving onto a moving
20 felt. The glass fibers are stitched or sewn onto each of the flexible fabric layers 18 and 28 separately, thus forming, in the preferred embodiment, individual glass containing layers, such as glass containing layers 124, 134, 234, 224, 334, 324, 824, 834, 24 and 34. These "layers" can be continuous or discontinuous, meaning that there may be gaps or undulations in the glass containing layers glass containing layers 124, 134, 234, 224, 334,
25 324, 824, 834, 24 and 34. The glass containing layers 24, 34, 124, 134, 234, 224, 324, 334, 824 and 834 may or may not be needled, stitched, flame bonded and/or adhesive bonded to themselves or to other components of the liner blocks 100, 200, 400, and 850; and liners 300, 500 and 600. Glass-faced flexible fabric layers made in accordance with these teachings are cut to size and, preferably, are joined by stitches 33, 233 or optional

stitch 833, which assembles them together as shown in FIGs. 3, 5 and 7. Optional stitch 833 can be used alternatively or in combination with a heat or resinous bond between the facing flexible fabric layers 218 and 238, or 838 and 818, for example, especially for total thicknesses exceeding 7 mm. Alternatively, glass containing layers 24, 34, 124, 134, 234, 324, 334, 824 and 834 can comprise preformed glass mats stitched or needled into the flexible fabric layer, for example. Additionally, instead of two glass containing layers, such as glass containing layers 24 and 34, a single layer, such as a double thickness glass layer, can be applied to one of the flexible fabric layers, such as flexible fabric layer 28, without adding glass fibers to the other, such as flexible fabric layer 18.

10 [0026] Liner or liner block 100 is illustrated to be nearly identical to liner block 200, which contains glass containing layers 124 and 134, and flexible fabric layers 148 and 138. However, since liner or liner block 100 is designed to be the innermost layer, following inversion, a substantially fluid resistant layer 20 is applied. With other liner systems, such fluid impermeable layers were provided by a fluid impermeable foil or
15 “calibration hose” which could be removed or left in place. The present invention desirably provides thinner flexible fabric layers 35 or 235, such as needled polyester felt layers having a thickness of about 1-3 mm. These flexible fabric layers 35 and 235 preferably contain a first surface, which contains flame-bondable fibers, for bonding to flexible fabric layer 18 and veil 228, for example. They also include a substantially fluid
20 impermeable layer 20, such as a coating, film or saturant, having a thickness of about .1-1 mm, so that the final thickness of the plastic-coated fabric is about 1.1-3mm, preferably about 1.2-1.8 mm. Preferably, the substantially fluid impermeable layer 20 is partially disposed within the porosity of the flexible fabric layers 35 and 235 to form a mechanical or melt bond.

25 [0027] With respect to liner or liner block 100, the flexible fabric 35, containing the substantially fluid impermeable layer 20, is heat bonded, such as by flame tacking, to the flexible fabric layer 18. In like manner, the flexible fabric layer 28 of liner 100 can be flame tacked to the flexible fabric layer 148 to form a melt bond 126. Melt bonds 26 and

126, as well as melt bonds 226 and 326, while strong, are temporary fastening measures, which become less important, or even irrelevant, once the resin is cured.

[0028] In the preferred inversion liner blocks 100, 200, 850 and 400, and liners 300, 500 and 600 of this invention, the glass fiber-containing layers 24, 34, 134, 124, 234, 5 224, 334, 324, 834 and 824 represent the reinforcement layers and are preferably of a thin cross-sectional thickness, such as less than 10 mm, preferably about .1-5 mm, and most preferably, about .6 mm, 1 mm and 1.5 mm for standard 4 mm, 6 mm and 9 mm building blocks, respectively. The flexible fabric layers 18, 28, 138, 148, 238, 218, 318, 328, 35, 818, 838 and 235 are preferably about .5-20 mm in thickness each, preferably 1-10 mm, 10 and most preferably about 1.33 mm, 2 mm and 3 mm for 4 mm, 6 mm, and 9 mm building blocks, respectively. Glass fiber-containing layers 24 and 34 in liner or liner block 100; layers 24, 34 and 124, 134 in composite liner 500; layers 24, 34, 124, 134 and 324, 334 in composite liner 600; and layers 824 and 834 in liner block 850, are desirably located radially outwardly, preferably less than 5 mm, and more preferably, less than 2.5 15 mm, from the outermost fabric-containing layers, prior to inversion, so as to provide flexural modulus and strength to the cured liner or liner blocks. Accordingly, glass fiber-containing layers, such as layers 124 and 134 of composite liner 600 of FIG. 6, can be optionally lightened or eliminated, since they are located along a neutral axis when the laminate is flexed and do not significantly contribute to the flexural performance of the 20 liner 600.

[0029] For the glass-faced liner or liner block 300, improved flexural modulus and strength is most desirably accomplished by placing the glass containing layer 224 no more than 2.5 mm from the liner's surface, and more preferably, within about 1.2-1.8 mm. Thicknesses for the plastic or resin coated flexible fabric layers 35 and 235 should 25 be about .1-3.0 mm, preferably about .25-2 mm, and more preferably about .75-1.25 mm. Additional flexible fabric layers (not shown) can be added, adjacent to layers 218 and 238, or these flexible fabric layers 218 and 238 can be thicker, such as 10-20 mm, to achieve final fabric thicknesses of up to 25-44 mm, for example. In addition, the glass fiber containing layers can be 1-5 mm, preferably 2-3 mm for thicker liners. The veil 228

should be as thin as possible while still permitting bonding (by heat or other methods) to the next flexible fabric layer. The veil 228 may have a thickness of only about .01-1 mm, preferably about .1-.3 mm. The impermeable layer itself should be less than 1 mm thick and, preferably, less than 0.5 mm thick, and can be applied to the veil 228, the thin
5 flexible fabric layer 235, or directly to the second glass containing layer 224, without any intermediate layers.

[0030] The preferred fabric layers 18, 35 and 28 of liner 100; fabric layers 138 and 148 of the second liner 200; fabric layers 238, 218, 228 and 235 of liner block 300; fabric layers 318 and 328 of liner block 400; and fabric layers 818 and 838 of block 850,
10 can be one or more sewn or bonded fabric layers, comprising a natural or synthetic fibrous material in needled, knit, woven or non-woven mat form. Suitable materials should be water and corrosion-resistant. Examples of fibers for such fabrics include pulp fiber, hemp, cotton, polyethylene, polypropylene, rayon, nylon and/or polyester fibers. In certain instances, woven or non-woven glass material can be used in addition to, or as a
15 substitute for, these other fibers. The most preferred embodiment for the fabric layers is a needle-punched non-woven polyester or acrylic felt employing standard technology for manufacturing needle-punched materials.

[0031] The glass fiber-containing layers 24, 34, 124,134, 234, 324, 224, 324, 334, 824 and 834 of this invention preferably contain chopped glass fibers, glass roving, or
20 both. Glass fiber compositions can include, for example, E, D, R, AR, S and/or C-type glass fibers. Such fibers can be blended with, or replaced by, thermoplastic (such as, polypropylene, polyamide, or polyethylene), or thermosetting, such as polyester, or other materials such as, carbon, graphite or basalt fiber. Alternatively, one hundred percent glass fibers can be distributed over the surface of flexible fabric layers 18, 28, 138, 148,
25 218, 238, 324, 334, 818 and 838, for example, and mechanically bonded thereto to produce a base layer for the liner blocks 100, 200, 400, and 850 and liner 300. This can be accomplished using a light needling process which keeps the majority of the glass fibers properly oriented, or more preferably, a stitch mat process, in which the preferred needle punched polyester mat is stitched to a plurality (about 200-2500 g/m²) of chopped

glass fibers on its top surface. The chopped glass fibers may, optionally, be added during production in several stages, which could be stitched down separately (such as in a “double glass” method). For example, up to about 1,000 g/m² of chopped glass fibers can be applied to a needle punched polyester mat. Then the fabric can be stitched and run
5 through the stitching machine a second time with an additional 1,000 g/m² of chopped class fibers. These processes result in a fiber glass-coated-polyester substrate laminate. Preferably, unidirectional polymer or glass rovings (750-2,200 tex) can also be provided in the machine direction or cross-machine direction, or in both directions, to allow for the handling of the resulting laminate without significant unintended stretching. Although a
10 uniform application of glass fibers is illustrated in the Figures, the glass fibers can be unevenly distributed on each or some of the fabric layers, or disposed in a double thickness on one fabric layer, such as fabric layer 28, while not applying any fibers to the other fabric layer, such as layer 18, prior to final stitching.

[0032] Because of the glass fiber reinforcement, the cured conduit liners of this
15 invention, for example, liners 500 of FIG. 4, 300 of FIG. 5 and 600 of FIG. 6, will have a flexural modulus of at least about 650 ksi and, typically, about 700-800 ksi or more, with a tensile strength of at least about 4,000-9,000 psi. The glass-faced liner 300 of FIG. 5 will have a modulus of about 700-800 ksi or more, due to the outer glass-containing layers 224 and 234 being located at or near the surface. These properties represent a
20 tremendous improvement over cured 100% polyester felt conduit liners, which are known to have a flexural modulus of less than 500 ksi, and commonly about 300-400 ksi. In these forms, this invention preferably uses a total of no more than about 5 mm, preferably less than 1-3 mm of glass, in each of the liner blocks 100, 200, in composite liners 500 and 300, with the balance being polyester or other fabric material. A full thickness 100%
25 glass liner could be used with some additional cost, such as, for example, by using a pair of needled glass felt layers with chopped glass and/or glass roving sandwiched therebetween. Alternatively, the glass component can be limited to the outermost liner blocks only, such as within liner blocks 100 and 400 in composite liner 600. The same would also apply to composite liners having 5, 7 and 9 liner blocks, for example.

[0033] In addition, a substantially fluid-impermeable layer 20 or 220, such as a membrane, coating, saturant, film or resinous latex coating, can be provided on fabric layers 35 and 235, and optionally on the innermost surface (prior to inversion) of the liner, such as fabric layers 28 and 138, or on glass-containing layer 234 of liner 300, to prevent fluid leakage and aid in pressurization. In the preferred embodiment, the fabric layers 35 and 235 are (1) painted or coated with a latex saturants such as polyurethane or acrylic, or (2) melt bonded to a polyethylene film, on one side only. In a preferred embodiment, a thin polyester felt of about .8-2 mm can be heat bonded to a thermoplastic film of about .3-.5 mm in thickness for a final thickness of about 1.2-2.3 mm.

[0034] In accordance with a preferred embodiment of this invention, shown in FIG. 7, a preferred liner block 850 has been manufactured by applying a substantially fluid impermeable layer 820 to a thin flexible fabric layer or veil 828 by the methods and materials discussed above. The substantially fluid impermeable layer 820 can be applied to the veil 828 and directly to the second glass-fiber containing layer 824. In preparing the liner 300, shown in FIG. 5, a coated polyester felt is typically supplied by an outside vendor, and is heat-bonded to the thin veil 228 by a heat bond 226. The present invention also envisions an improved construction method whereby the fabric layer 235 of FIG. 5 can be eliminated. This improved method of manufacturing a tubular inversion liner block 850, includes the steps of providing a first flexible fabric layer 838 fastened to a first glass fiber containing layer 834 and providing a second flexible fabric layer 818 fastened to second glass fiber containing layer 824. The method then combines the first and second flexible fabric layers 838 and 818 and the first and second glass fiber containing layers 834 and 824 so that the first and second flexible fabric layers 838 and 818 face one another and are sandwiched between the first and second glass fiber containing layers 834 and 824. For thicker liners, additional flexible fabric layers can be added to layers 838 and 818, or these layers 838 and 818, and the glass fiber containing layers 834 and 824, can be made thicker, as set forth by way of example, in connection with the description of liner 300. A third flexible fabric layer 828, preferably a thinner flexible fabric of the same or similar material, such as a veil, as described herein, is attached to one of the glass containing layers 824 or 834. In addition, a substantially fluid

impermeable layer 820, much like the fluid impermeable layers 20 and 220 defined herein, is joined to the third flexible fabric layer 828, or directly to one of the glass containing layers 824 or 834. When the substantially fluid impermeable layer 820 is joined to the third flexible fabric layer 828 or to the second glass fiber containing layer 824 by adhesive, glue, solvent, flame, melt-bond, or stitching, for example, the substantially fluid impermeable layer 820 becomes the outermost layer, and the first or other glass fiber containing layer 834 can become the innermost layer of the inversion liner or liner block 850 prior to inversion. In a preferred embodiment, the substantially fluid impermeable layer 820 is applied by (1) directly coating a plastic film or painting a resinous layer, for example, onto the thin nonwoven veil or layer 828, after it and the other layers of liner block 850 have been stitched together, or (2) by separately applying a plastic film, resinous fluid or latex layer onto the third flexible fabric layer 828 prior to stitching or joining to the remaining layers of the block 850, or (3) by layering a substantially fluid impermeable layer 820 with one of the glass fiber containing layers and flexible fabric layers before they are all stitched together.

[0035] In typical fashion, the third flexible fabric layer 828 can be stitched to the second glass fiber containing layer 824 and second flexible fabric layer 818 at the same time the latter two layers are stitched. Alternatively, the third flexible fabric layer 828 could be stitched at the same time as the first and second flexible fabric layers 838 and 818, and their attendant glass fiber containing layers 834 and 824, are stitched together. This practice is more desirable when a total thickness of layers 834, 838, 818, 824 and 820 is less than about 7 mm. Otherwise, it is envisioned that the first and second flexible fabric layers 838 and 818 would, preferably, be heat or resin-bonded, such as disclosed by heat or resin bonds 26,126 or 326. After heat or resin bonding the flexible fabric layers 838 and 818 together, a coated felt, such as flexible fabric layer 235 of FIG. 5 and its substantially fluid impermeable layer 220, can be heat-bonded to the veil, such as veil 828, in this assembly variation.

[0036] For reasons of functionality and aesthetics, a veil or thin flexible fabric layer can also be added to the surface of the first glass containing layer 834, which will

eventually become the outermost layer after inversion. This will contain loose fibers from being removed from the liner, which could possibly cause irritation during handling.

[0037] The membrane, film, coating or layer, such as substantially impermeable layers 20, 220 and 820, should be substantially impermeable to fluids, such as air, steam or water, at a pressure of less than 1 atmosphere (15 psi), preferably about 3-5 psi, and temperatures of about 100-260°F. For example, in one exemplary hot water cure system of this invention, the temperature of the water can be cycled up to 180-190°F. More specifically, the heat can be applied from one side, ramped from ambient to 180°F over 3-4 hours, and held at 140°F for one-half hour. The exothermic reaction for a thermosetting resin can occur, for example, during the 140°F hold, and peak at 250-260°F. A temperature of 180°F is maintained for 3 hours, then the liner is cooled at a rate of no higher than about 15°F per hour down to about 10°F over ambient. The substantially impermeable layers 20, 220 and 820 can be attached to a thin flexible fabric layer, such as a veil 228, or attached directly to a thicker flexible fabric layer, such as layers 235 or 18, or directly attached to a glass fiber containing layer, such as layers 224, 24 or 824, via adhesive, glue, solvent, flame, melt-bond or stitching for example.

[0038] The liners 300, 500 and 600, and blocks 100, 200, 400 and 850 of this invention are designed to be impregnated with a curable or settable resin. The resinous impregnation liquid introduced into the fabric layers 18, 28, 35, 138, 148, 218, 238, 228, 235, 838, 818, 318, and/or 328, glass fiber-containing layers 24, 34, 134, 124, 834, 824 and/or 224, or within all or some of these layers, can be any number of thermosetting or thermoplastic compositions which can be introduced by dipping, injecting, extruding or painting, for example. The resinous impregnation liquid becomes set or hardened by light or heat to provide a solid matrix around the fibers. Suitable thermoplastic compositions include thermoplastic polyvinyl chloride, polyolefins, and the like. Suitable thermosetting resins can include those containing a heat-activatable curing agent, a light-activatable agent, a curing agent, or a heat deactivatable curing retarding agent. Such examples include ultraviolet curing unsaturated polyester, such as disclosed in U.S. Pat.

No. 6,170,531, incorporated herein by reference, vinyl ester, epoxy and thermosetting polyester.

[0039] The liners 300, 500 and 600, and optionally, liner blocks 100, 200, 850 and 400 of this invention further include an adhesive, glue, solvent, flame and/or melt bonds 5 26, 126, 226 and 326. The bonds 26, 126, 226 and 326 preferably include a flame or melt bond between molten fibers of polyester felt or polyolefin fibers, for example. The bonds 26, 126, 226 and 326 preferably "tack" the adjoining layers together so that they can be resin impregnated, inserted into a pipe and inverted under pressure without breaking 10 apart. Curing of the resinous saturant will provide the final bond between fabric and glass layers to provide the final tensile and flexural strength.

[0040] With respect to FIG. 1, one procedure for inserting the preferred inversion liner 500 of this invention will now be described. This improved method is designed to repair a crack in a ruptured underground conduit 12, such as pipes, mains or drains. Man holes, when not already present, can be provided on opposite sides of the ruptured pipe 15 sections after the pipe 12 has been suitably emptied and the particular section is uncoupled from adjacent sections. The unexpanded inversion liner 500, containing the composite liner portions 100 and 200 of FIG. 4, is then inserted into the cleaned pipe 12, the free end 11 is then inverted and clamped by fasteners 13 to the feed elbow 22. Hot 20 pressured fluids, such as steam, air or water can be pumped into the liner 500 until it completely inverts and expands. This pressure can remain within the liner 500 until the thermosetting or thermoplastic resin impregnated therein sets or cures. The free end of the liner 500 can then be removed from the elbow 22 and the repaired section of the pipe 12 re-coupled to the adjacent pipe sections. The liners and liner blocks 100, 200, 300, 500, 600 and 850 of this invention may also be used with new or undamaged conduit 25 before installation, or can be used to manufacture original equipment piping and conduit, as a liner, or as a stand alone product.

[0041] From the foregoing, it can be realized that this invention provides improved inversion liners having reinforced glass fiber-containing layers for improving

the hoop and longitudinal strength of the liner material, while providing a heat or light-activatable saturant for curing. Although various embodiments have been illustrated, this is for the purpose of describing, but not limiting the invention. Various modifications, which will become apparent to one skilled in the art, are within the scope of this invention

5 described in the attached claims.

What is claimed:

1. A pressure-expandable tubular liner 300 for conduits, including at least one liner block, characterized by:
 - 5 (a) a first flexible fabric layer 238 fastened to a first high strength fiber containing layer 234;
 - (b) a second flexible fabric layer 218 fastened to a second high strength fiber containing layer 224;
 - 10 (c) said first and second flexible fabric layers 238 and 218 and said first and second high strength fiber containing layers 234 and 224 fastened together whereby said first and second flexible fabric layers 238, 218 face one another and are sandwiched between said first and second fiber containing layers 234, 224; and
 - 15 (d) a substantially fluid impermeable layer 220 joined to at least one of said high strength fiber containing layers 224, 234.
2. The tubular inversion liner of claim 1 wherein said first and second flexible fabric layers comprise a nonwoven polyester felt.
- 20 3. The tubular inversion liner of claim 2 wherein said first and second high strength fiber layers comprise chopped glass fibers and glass roving.
4. The tubular inversion liner of claim 1 wherein said substantially fluid impermeable layer comprises one or more of: a veil, a resinous membrane, or
25 resinous coating.
5. The tubular inversion liner of claim 4 wherein said fluid impermeable layer comprises a polyurethane coating which is adhered to a first surface portion of one or both of said glass fiber containing layers.

30

- 5 6. The tubular inversion liner of claim 1 wherein said fluid impermeable layer
comprises a polymer film integrally bonded to a felt, veil or both.
7. The tubular inversion liner of claim 1 wherein said liner is impregnated with a
10 heat curable or light curable resin, and cured to produce a flexural modulus of at
least about 650 ksi.
8. The tubular inversion liner of claim 1 comprising an additional flexible fabric
layer, high strength fiber containing layer, or both, disposed between said first and
15 second flexible fabric layers.
9. The tubular inversion liner of claim 1 having an inversion rate which is at least
10% faster than the inversion rate for a 100% polyester felt liner of like
dimensions.
- 20 10. The tubular liner of claim 1 wherein said liner is an inversion liner and said
substantially fluid impermeable layer becomes the outermost layer prior to inversion,
and the innermost layer following inversion.

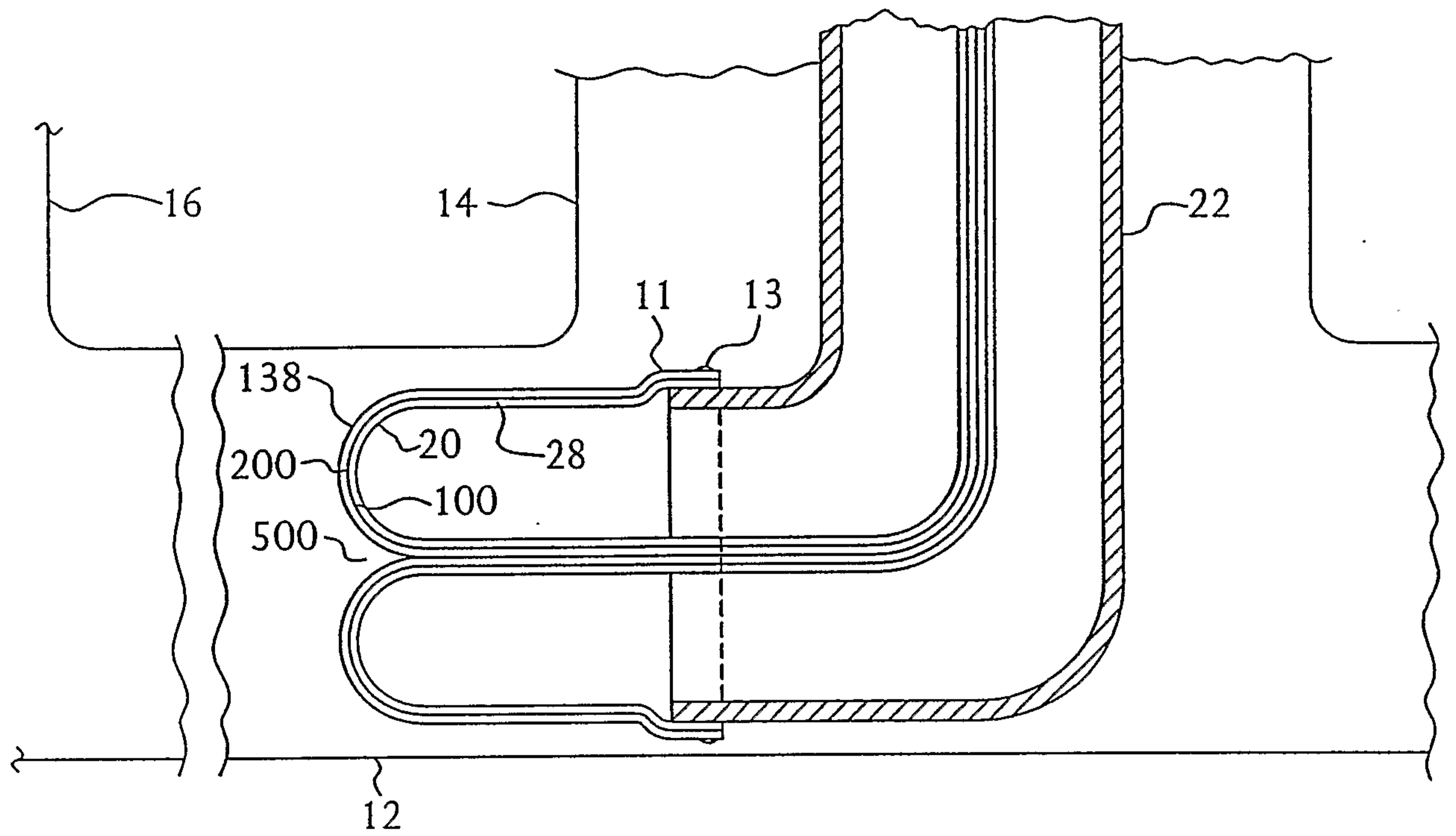


FIG. 1

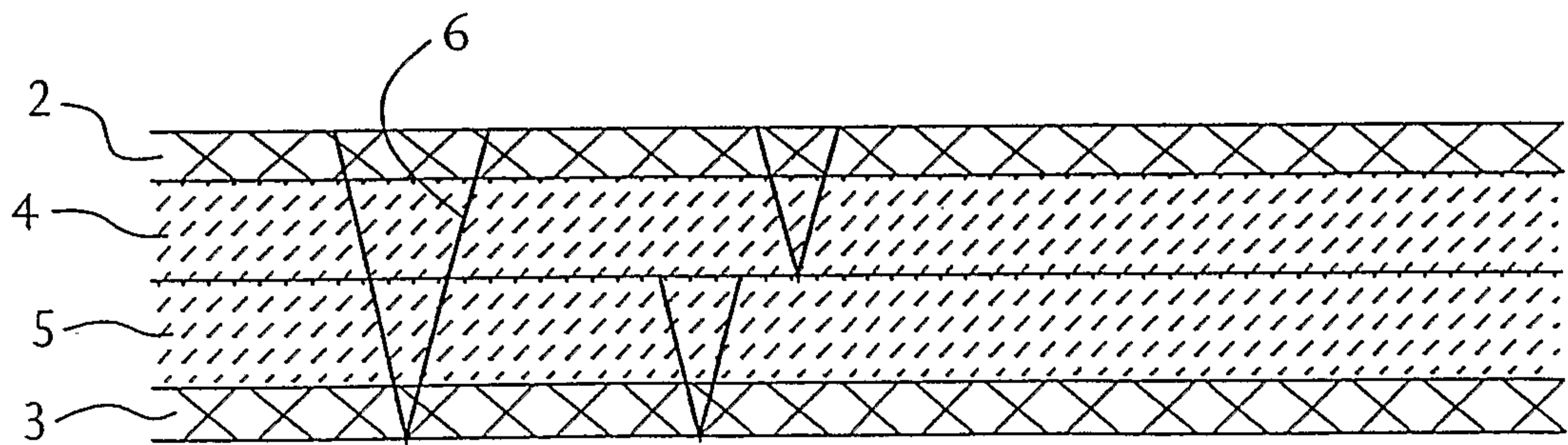


FIG. 2

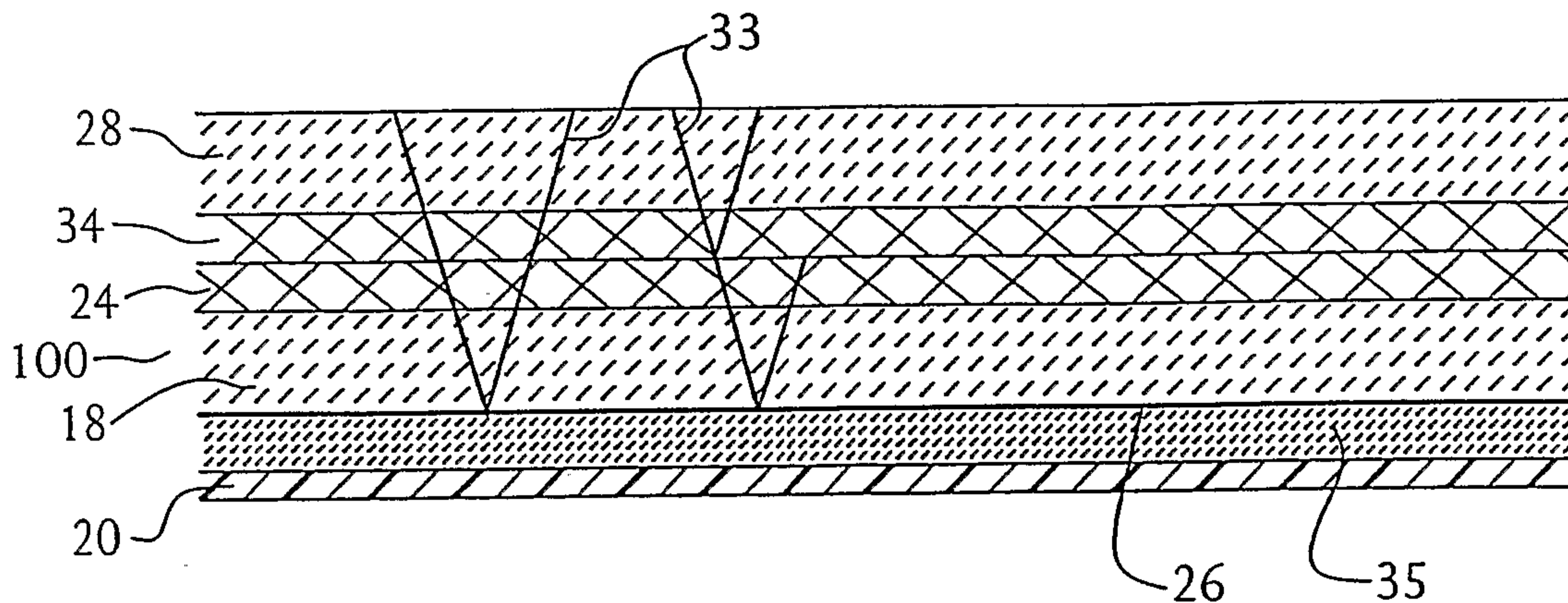


FIG. 3

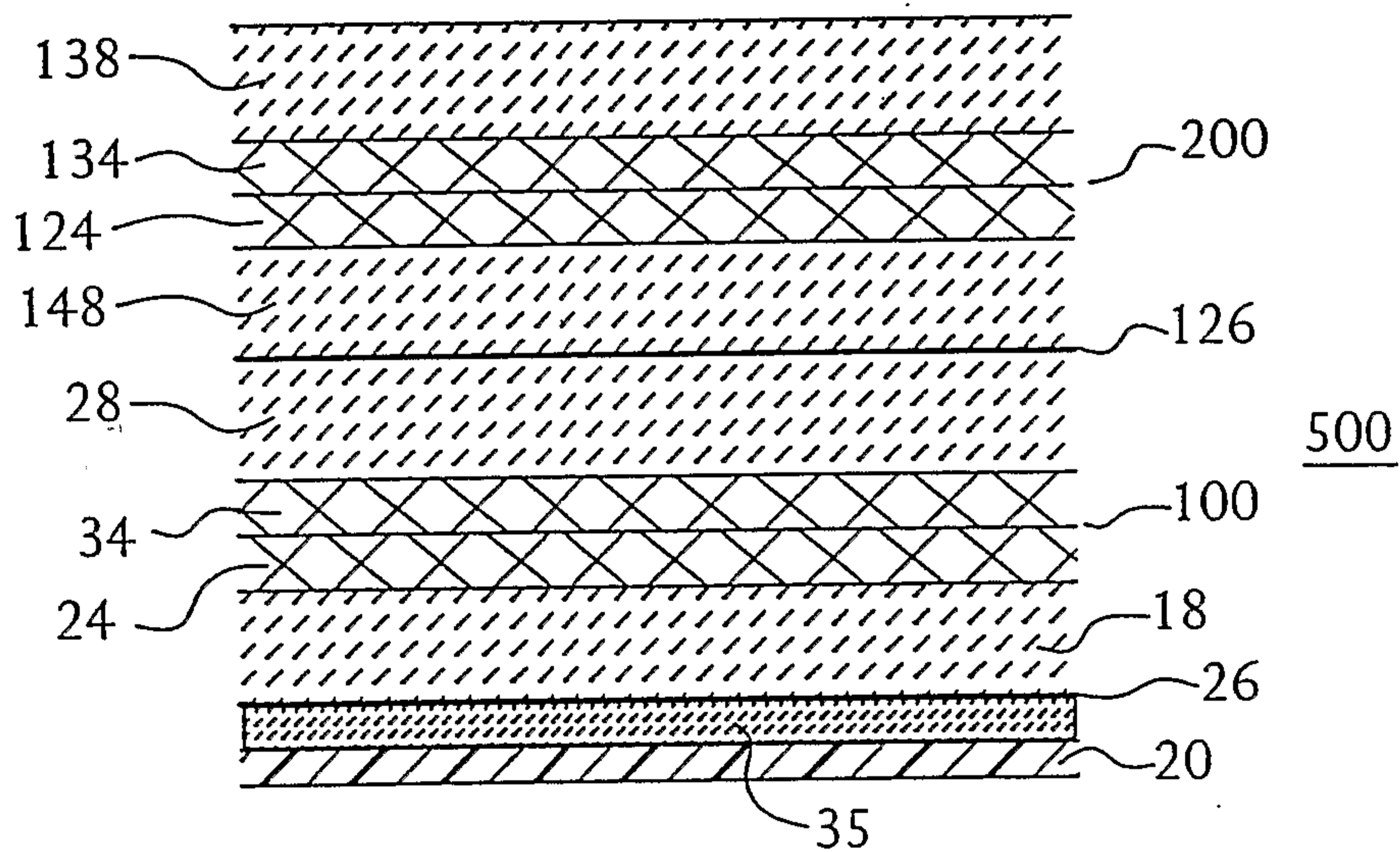


FIG. 4

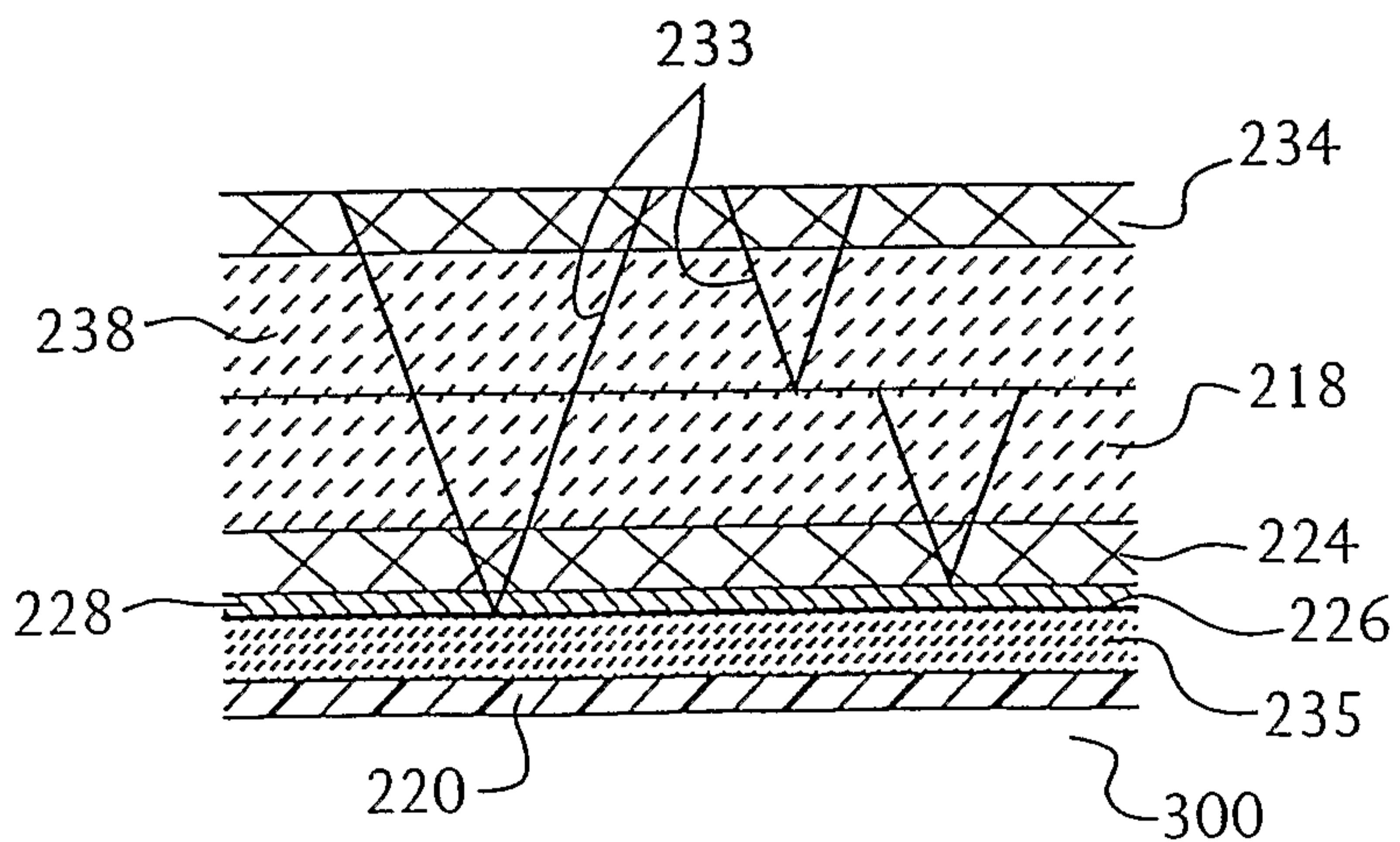


FIG. 5

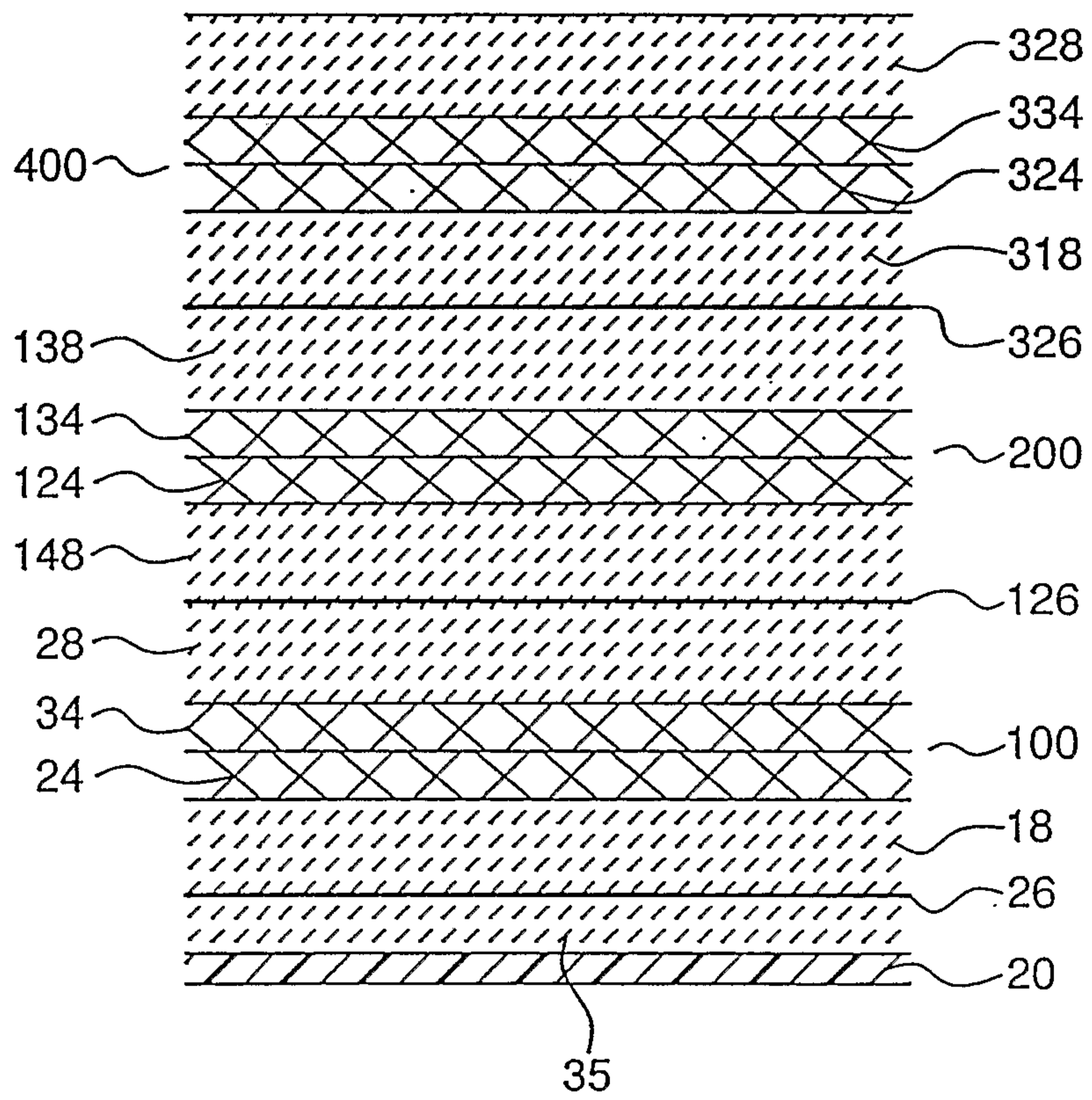


FIG. 6

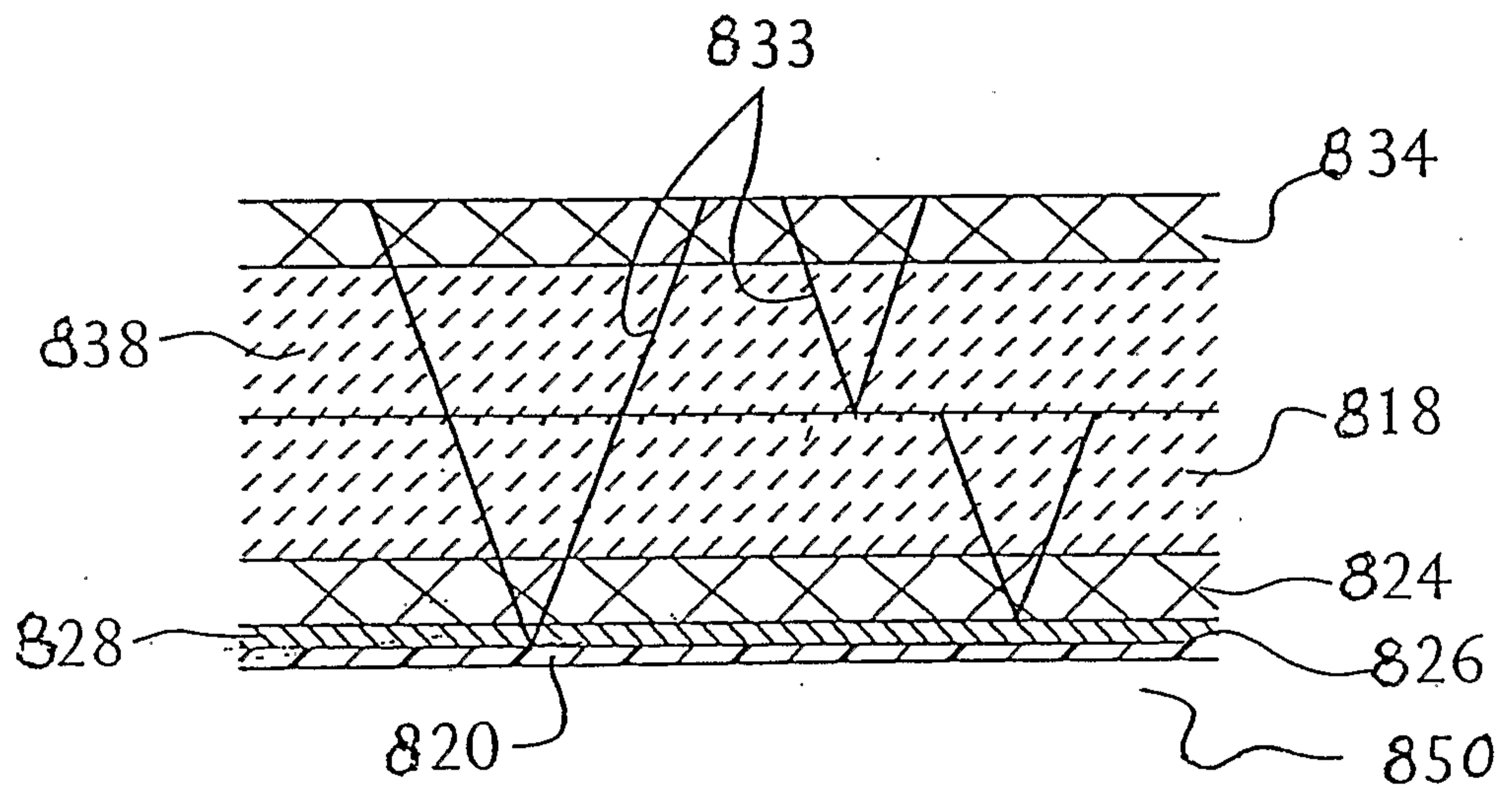


FIG.7

