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(71) Applicant:  
**Armstrong World Industries, Inc.  
Lancaster Pennsylvania 17603 (US)**

(72) Inventors:  
• **Frantz, William H,  
Elizabethtown, PA 17022 (US)**

• **Felegi, John, Jr.  
Lancaster, PA 17603 (US)**  
• **Patel, Kartik A,  
Landisville, PA 17538 (US)**  
• **Wiker, Anthony L,  
Lancaster, PA 17601 (US)**

(74) Representative:  
**Hofstetter, Alfons J., Dr.rer.nat. et al  
Strasse & Hofstetter,  
Balanstrasse 57  
81541 München (DE)**

(54) **Reinforced ceiling panels**

(57) The disclosure is for laminated reinforced fiber panels constructed of materials which would not be self supporting as individual layers. The panel is constructed with the center core structure (12) being a flexible fiber mat and the two outside reinforcing layers (14,16) adding just sufficient strength to prevent the entire panel from sagging. The reinforcing layers can be scrim, metal foil, metal foil and paper laminate, or mineral board, and they can be embossed or corrugated to add strength without additional material and weight.

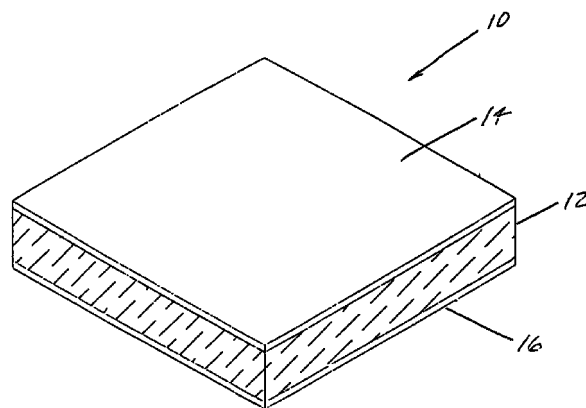


FIG. 1

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## Description

### BACKGROUND OF THE INVENTION

[0001] This invention deals generally with ceiling and wall panels and more specifically with an acoustical, fire retardant ceiling panel which is constructed with a flexible, low density core and is reinforced so that sag will be deterred, and it will pass standard surface burning tests.

[0002] Acoustic ceiling panels have always been required to have certain properties such as sound absorbency, fire retardation, rigidity, and light weight, but current consumer attitudes and government regulations have added new, more stringent, requirements. For example, it is now desirable to construct panels with materials which are "natural", which have been or can be recycled, which release no fibers from the finished product, and, of course, which are economical. For purposes of this document, the common definition of "natural", as materials made from animal or vegetable matter, is being used. A more subtle desirable quality is that the raw material used be a renewable resource.

[0003] In our present culture the use of large quantities of fiberglass or other man made fibers for the panel core material is undesirable. However, untreated natural materials such as cotton must be compressed to a very dense structure before they become rigid enough to prevent unacceptable moisture induced sag in a ceiling panel with an unsupported span as long as four feet.

[0004] The availability of an inexpensive ceiling panel made with natural, recyclable, and renewable fibers, but rigid enough to prevent excessive sag over a long span, would be very advantageous.

### SUMMARY OF THE INVENTION

[0005] The present invention is a planar, reinforced ceiling panel with a low density, natural, fiber core structure sandwiched between two reinforcing layers. The core itself is very flexible and has no significant self support, but in combination with the two reinforcing layers between which it is captured, it forms a panel which is rigid enough to have acceptable sag characteristics. The three layers are constructed of specifically selected materials and structures to yield a sag resistant, non-shedding panel which yields the desirable acoustical and fire retardant qualities.

[0006] The first reinforcing layer, preferably the layer which will become the exposed and visible surface of a ceiling, is a scrim layer. This is a veil-like layer of fibers which have significant space between adjacent fibers, but intersecting fibers are attached to each other. Although such a scrim could be made of woven material, for economy a non-woven scrim is preferred. In a non-woven scrim the randomly oriented intersecting fibers are attached to each other by means of a binder. This first reinforcing layer is attached to one planar surface of the core structure by the use of conventional

techniques, such as with adhesives.

[0007] The second reinforcing layer is attached to the opposite planar surface of the core structure to essentially enclose the core structure. In the preferred embodiment this second reinforcing layer is another scrim layer, but it can also be constructed differently. One alternate embodiment has the second reinforcing layer as a single thickness of metal foil. The invention also improves the acoustic properties of the panel when the second reinforcing layer is constructed of metal foil with small punched holes throughout the layer.

[0008] Another embodiment of the invention forms the second reinforcing layer of metal foil with ribs, corrugations, or embossed patterns to substantially increase the rigidity of the whole panel while using thinner material such as metal foil. Another version of the invention makes the second reinforcing layer of metal foil laminated to paper, and still another embodiment is constructed with a layer of mineral board used as the second reinforcing layer.

[0009] Furthermore, the fully assembled panel can satisfactorily meet fire retardancy criteria, even when the core structure is constructed of desirable but flammable materials such as waste cotton, as long as the two reinforcing layers are attached to the core structure by means which assure that the reinforcing layers remain attached to the core structure even when the panel is exposed to fire.

[0010] Each of the core structure and reinforcing layers is constructed with certain specific materials, weights, densities, and thicknesses so that the finished ceiling panels meet the standard test of flexural stiffness after a severe humidity cycle, even with recycled or recyclable materials, and with the added acoustical and fire retardancy properties, the invention provides an economical and easily manufactured ceiling panel.

### BRIEF DESCRIPTION OF THE DRAWINGS

[0011]

FIG. 1 is a perspective view of the preferred embodiment of the invention.

FIG. 2 is a perspective view of an alternate embodiment of the invention in which one reinforcing layer has random through holes formed throughout it to improve its acoustic characteristics.

FIG. 3 is a perspective view of an alternate embodiment of the invention in which one reinforcing layer has ribs.

FIG. 4 is a perspective view of an alternate embodiment of the invention in which one reinforcing layer is corrugated.

FIG. 5 is a perspective view of an alternate embodiment of the invention in which one reinforcing layer is embossed.

FIG. 6 is a perspective view of an alternate embodiment of the invention in which one reinforcing layer

is laminated.

#### DETAILED DESCRIPTION OF THE INVENTION

**[0012]** FIG. 1 is a perspective view of preferred embodiment of the invention in which panel 10 is constructed of simple parts, core 12, first reinforcing layer 14 and second reinforcing layer 16. Although the simple appearance of FIG. 1 is similar to that of many prior art panels it is the particular structures, compositions, thicknesses, and densities of layers 12, 14, and 16 which provide the uniqueness of the invention.

**[0013]** Core 12 is constructed as a fibrous flexible mat preferably produced from waste textile fiber such as cotton, linen, and wool. Alternatively, vegetable fibers such as flax, hemp, kenaf, straw, waste paper, and wood fiber or synthetic fibers such as mineral wool, fiberglass, and nylon, or metal fibers are used to produce the core. Fillers such as kaolin clay, calcium carbonate, talc, mica, Wollastonite, or inorganic flame retardant fillers are also used within the core. The preferred embodiment of core 12 is a mixture of 40 percent by weight of waste textile or vegetable fibers or a blend of them, with the balance of the core being fillers or synthetic fibers or a blend of them and binders of polyester, polyethylene, or polypropylene or a blend of them. The range of the mixture can vary from at least 20 percent by weight of waste cotton to 100 percent. Core 12 is conventionally treated with fire retardant materials as is well understood in the art of making ceiling panels.

**[0014]** However, the fire retardancy of finished panel 10 is substantially enhanced by the construction of the panel. When reinforcing layers 14 and 16 are attached to core structure 12 by a means which assures that layers 14 and 16 will remain attached to core 12 even when the panel is exposed to fire, the panel meets the fire requirements for a class A material as specified in ASTM E1264 when subjected to ASTM E84 (also identified as UL 723), the Test For Surface Burning Characteristics of Building Materials.

**[0015]** The means of attaching layers 14 and 16 so that they do not separate from core 12 when exposed to fire can be either mechanical, such as by the process known in the art as needle punching, or by appropriate adhesives. A typical adhesive which is used is polyvinyl acetate, such as H.B. Fuller type C-6052.

**[0016]** Suitable thicknesses of core 12 range from 0.25 to 1.25 inch with the preferred thickness in the range of between 0.5 and 0.8 inch. Suitable densities of core 12 range from 1 to 15 pounds per cubic foot with the preferred densities in the range of between 3 and 6 pounds per cubic foot. Densities greater than the preferred range increase the cost of the panels and reduce the acoustic performance, while densities below the preferred range yield insufficient strength. The preferred densities are much lower than the densities of cores in prior art panels, and unlike prior art cores, core 12 of the invention is, by itself, very flexible with no significant self

support. Binder levels within core 12 range from 8 to 25 percent by weight, with the preferred level in the range between 10 and 20 percent by weight. Binder levels can be reduced to less than 10 percent by weight when the core is further consolidated by conventional needle punching processes.

**[0017]** The un-reinforced core structure is tested for stiffness according to a modified cantilever test similar to ASTM D5732, the "Standard Test Method for Stiffness of Nonwoven Fabrics using the Cantilever Test". The standard test is modified to use a 3 inch wide by 24 inch long strip of core structure material, and the measurement is made after conditioning the sample at 50 percent relative humidity and 82 degrees F. for 24 hours. The strip is supported as a cantilever beam, and the overhanging length of the strip is gradually increased until the free end of the strip deflects downward by 2 inches from its own weight. The length of the overhang, "the bending length", when the deflection reaches 2 inches is then recorded. Larger values of bending length indicate increased stiffness of the unreinforced core structure. The present invention permits the use of core structures having an initial bending length in the range of between 3 inches and 24 inches to construct satisfactory ceiling panels. For this invention, "not self supporting" is defined as a 3 inch wide by 24 inch long strip having a bending length less than 20 inches and preferably less than 15 inches.

**[0018]** For the preferred embodiment, first reinforcing layer 14 and second reinforcing layer 16 are both scrims. Each scrim is a veil-like layer of fibers which has significant space between adjacent fibers, with intersecting fibers attached to each other. For economy, reinforcing layers 14 and 16 are non-woven scrims in which randomly oriented intersecting fibers are attached to each other by means of a binder.

**[0019]** Suitable materials for scrims used as reinforcing layers 14 and 16 are fiberglass, mineral fibers, blends of cellulose and mineral fibers, and polyester. The structure of the preferred embodiment is a non-woven scrim of fiberglass. Suitable thicknesses range from 0.005 to 0.040 inch with the preferred range of thickness between 0.016 to 0.036 inch. Suitable basis weights range from 10 to 125 grams per square meter with the preferred range from 50 to 85 grams per square meter.

**[0020]** The outer surfaces of reinforcing layers 14 and 16 may also be finished with paint to provide decoration, increase surface durability, provide additional reinforcing, provide light reflectance, and achieve desirable air-flow permeability for sound absorption.

**[0021]** Even though panel 10 of the preferred embodiment of the invention includes core 12 which is not itself self supporting, panel 10 does pass a standard test for flexural stiffness after being subjected to conditions of high humidity.

**[0022]** Finished panels are tested by the methods described in ASTM C367, the "Standard Test Methods

for Strength Properties of Prefabricated Architectural Acoustic Tile or Lay-in Ceiling Panels". Initial deflection readings are made at 35 percent relative humidity and 82 degrees F. Final deflection readings are made at 90 percent relative humidity and 82 degrees F. The total test time is 96 hours. Each embodiment of the present invention is a rigid panel which has final deflection values of less than 0.250 inch, and more preferably less than 0.125 inch, when tested as a 2 foot square panel.

**[0023]** An even more dramatic result occurs because many panels actually fall from their supports when they are supported on only their four edges and are subjected to the humidity conditions described above. The panel of the invention therefore demonstrates its clear superiority by merely remaining suspended from its edge supporting grid.

**[0024]** FIG. 1 is also an accurate depiction of two alternative embodiments of the invention in which at least one of the reinforcing layers is constructed differently from the description above which uses two scrims. One alternate embodiment replaces at least one of the reinforcing layers 14 and 16 with metal foil. Suitable foils for use in reinforcing layers 14 and 16 include steel, aluminum, tin, and their alloys. The preferred material is aluminum. Suitable foil thicknesses are in the range of thicknesses between 0.001 inch and 0.010 inch and the preferred thicknesses are in the range between 0.001 and 0.003 inch, however, to pass the Surface Burning test discussed above, the aluminum foil must be at least 0.002 inch thick.

**[0025]** Another alternate material for use as reinforcing layers 14 and 16 of FIG. 1 is mineral fiber board. Suitable fiber board which can be used for at least one of the reinforcing layers 14 and 16 includes those wet formed from slurries known in the art, such as those containing mineral fiber, perlite, waste paper, and clay, along with a suitable binder to form the mass into a rigid board. Appropriate densities for such boards are in the range between 8 and 24 pounds per cubic foot with the preferred density in the range between 12 and 18 pounds per cubic foot. Such rigid boards can vary in thickness between 0.100 and 0.800 inch with the preferred thickness between 0.250 and 0.375 inch.

**[0026]** FIG. 2 is a perspective view of an alternate embodiment of the invention in which one reinforcing layer 15 has random through holes 17 formed through-out it to improve its acoustic characteristics. The preferred structure of this embodiment is a random pattern of 2000 holes per square foot with the holes of 0.030 inch diameter. 900 holes per square foot with 0.035 inch diameter holes has also been tested. The open area formed by the holes should be in the range between 0.25 and 2.0 percent.

**[0027]** Such panels have been subjected to the Noise Reduction Coefficient Test, ASTM C423 with an E-400 mounting as described in ASTM E795. In such tests, 0.500 inch panels composed of a painted scrim first reinforcing layer, a core structure of 85 percent cotton

and 15 percent polyester binder, and a 0.001 inch aluminum foil second reinforcing layer without holes gave a 4 frequency average absorption coefficient of 0.810. The same panel, but with the aluminum foil having 0.030 inch holes at 2000 holes per square foot, yielded a 4 frequency average absorption coefficient of 0.863. This increase in absorption is an increase in one NRC class, from 80 NRC to 85 NRC.

**[0028]** FIG. 3 is a perspective view of an alternate embodiment of the invention in which panel 20 has one reinforcing layer 22 with ribs 24. With this type of structure the flexural stiffness is greatly increased and panel 20 exhibits a greatly reduced mid-panel deflection.

**[0029]** FIG. 4 is a perspective view of an alternate embodiment of the invention in which panel 30 has one reinforcing layer 32 which is corrugated. Corrugations 34 function in the same manner as ribs 24 of FIG. 3 to strengthen panel 30.

**[0030]** FIG. 5 shows still another example of a strengthening structure in which panel 40 has superior strength because reinforcing layer 42 is embossed. In a general sense, any raised structure in a reinforcing layer adds to the strength of the panel. In FIG. 5 embossed pattern 44 creates portions of the structure, such as peaks 46, which are not in the same plane as valleys 48, the portion of the structure which is in the plane of the surface of the core, and therefore peaks 46 strengthen the panel.

**[0031]** FIG. 6 is a perspective view of another alternate embodiment of the invention in which one reinforcing layer 52 of panel 50 is a laminated structure. The use of metal foil layer 54 which is laminated to paper layer 56, permits the use of much thinner metal foils than those previous described in regard to FIG. 1, and reduces the cost. While the metals used are the same as previously listed, steel, aluminum, tin and their alloys, the thicknesses used for metal foil 54 are an order of magnitude less. Typical foils are in the range of between 0.0001 and 0.001 inch, and the preferred embodiment uses aluminum foil with thicknesses in the range between 0.0004 and 0.0005 inch. Paper layer 56 is then typically 0.002 to 0.010 inch thick, and in the preferred embodiment paper layer 56 is in the range between 0.003 and 0.006 inch. The typical paper weights range from 25 to 140 grams per square meter, and in the preferred embodiment paper layer 56 is in the range between 40 and 90 grams per square meter.

**[0032]** It is to be understood that the form of this invention as shown is merely a preferred embodiment. Various changes may be made in the function and arrangement of parts; equivalent means may be substituted for those illustrated and described; and certain features may be used independently from others without departing from the spirit and scope of the invention as defined in the following claims.

**[0033]** For example, both reinforcing layers of any panel could be constructed with an alternate material such as metal foil, paper laminated to metal foil, or min-

eral fiber, or an alternate structure such as a ribbed corrugated, or embossed structure. Furthermore, the two reinforcing layers could be constructed with different alternate structures or materials.

**[0034]** What is claimed as new and for which Letters patent of the United States are desired to be secured is:

### Claims

#### 1. A ceiling panel comprising:

a core structure with two opposed surfaces, the core structure being a flexible mat of such materials and thickness that it is not self supporting;

a first reinforcing layer attached to one opposed surface of the core structure and constructed as a scrim; and

a second reinforcing layer attached to the second opposed surface of the core structure, with the second reinforcing layer constructed to have sufficient strength so that the combination of the core structure and the first and second reinforcing layers forms a rigid ceiling panel.

2. The ceiling panel of claim 1 wherein the rigid ceiling panel formed has a deflection of less than 0.250 inch when tested as a 2 foot square panel under ASTM C367 conditions after being subjected to 90 percent relative humidity and 82 degrees F. for 96 hours.

3. The ceiling panel of claim 1 wherein the core structure is no thicker than 1.25 inches.

4. The ceiling panel of claim 1 wherein the density of the core structure is no greater than 15 pounds per cubic foot.

5. The ceiling panel of claim 1 wherein the core structure is constructed with at least twenty percent natural materials by weight.

6. The ceiling panel of claim 1 wherein the core structure has a bending length of less than 20 inches when tested as a 3 inch wide by 24 inch long strip under the conditions of ASTM D5732.

7. The ceiling panel of claim 1 wherein the scrim is constructed as a non-woven material.

8. The ceiling panel of claim 1 wherein the thickness of the scrim is no greater than 0.040 inch.

9. The ceiling panel of claim 2 wherein the rigid ceiling panel formed has a deflection of less than 0.125 inch when tested as a 2 foot square panel under ASTM C367 conditions after being subjected to 90

percent relative humidity and 82 degrees F. for 96 hours.

10. The ceiling panel of claim 1 wherein the second reinforcing layer is constructed as a scrim.

11. The ceiling panel of claim 1 wherein the second reinforcing layer is constructed with ribs.

12. The ceiling panel of claim 1 wherein the second reinforcing layer is corrugated.

13. The ceiling panel of claim 1 wherein the second reinforcing layer is embossed.

14. The ceiling panel of claim 1 wherein the second reinforcing layer is metal foil.

15. The ceiling panel of claim 14 wherein the thickness of the metal foil is no greater than 0.010 inch.

16. The ceiling panel of claim 1 wherein the second reinforcing layer is metal foil with holes formed in the foil.

17. The ceiling panel of claim 1 wherein the second reinforcing layer is metal foil with holes formed in the foil, and the holes provide an open area in the range of between 0.25 percent and 2.0 percent.

18. The ceiling panel of claim 1 wherein the second reinforcing layer is a laminated layer.

19. The ceiling panel of claim 18 wherein the second reinforcing layer is metal foil laminated to paper.

20. The ceiling panel of claim 19 wherein the thickness of the metal layer laminated to the paper is no greater than 0.001 inch.

21. The ceiling panel of claim 1 wherein the second reinforcing layer is mineral fiber board.

22. The ceiling panel of claim 1 wherein at least one reinforcing layer is painted.

23. The ceiling panel of claim 1 wherein the reinforcing layers are attached to the core structure by means which maintains the attachment when the panel is exposed to fire under ASTM E84 test conditions.

#### 24. A ceiling panel comprising:

a core structure with two opposed surfaces, the core structure being a flexible mat of such materials and thickness that it is not self supporting;

a first reinforcing layer attached to one

opposed surface of the core structure and constructed as a scrim; and

a second reinforcing layer attached to the second opposed surface of the core structure, with the second reinforcing layer constructed to have sufficient strength so that the combination of the core structure and the first and second reinforcing layers forms a ceiling panel which will not fall from supports which are located at only the four edges of the panel.

**25. A ceiling panel comprising:**

a core structure with two opposed surfaces, the core structure being a flexible mat of such materials and thickness that it is not self supporting;

a first reinforcing layer attached to one opposed surface of the core structure and constructed as a scrim;

a second reinforcing layer attached to the second opposed surface of the core structure; and the reinforcing layers attached to the core structure by means which maintains the attachment when the panel is exposed to fire under ASTM E84 test conditions;

whereby the ceiling panel meets the fire requirements for a Class A material as defined by ASTM E1264, when subjected to ASTM E84, the Test for Surface Burning Characteristics of Building Materials.

**26. A ceiling panel comprising:**

a core structure with two opposed surfaces, the core structure being a flexible mat of at least 20 percent natural fibers;

a first reinforcing layer attached to one opposed surface of the core structure;

a second reinforcing layer attached to the second opposed surface of the core structure; and the reinforcing layers attached to the core structure by means which maintains the attachment when the panel is exposed to fire under ASTM E84 test conditions;

whereby the ceiling panel meets the fire requirements for a Class A material as defined by ASTM E1264, when subjected to ASTM E84, the Test for Surface Burning Characteristics of Building Materials.

**27. The ceiling panel of claim 26 wherein the core structure includes at least 50 percent natural fibers.**

**28. The ceiling panel of claim 26 wherein one reinforcing layer is aluminum foil with a thickness of at least 0.002 inch.**

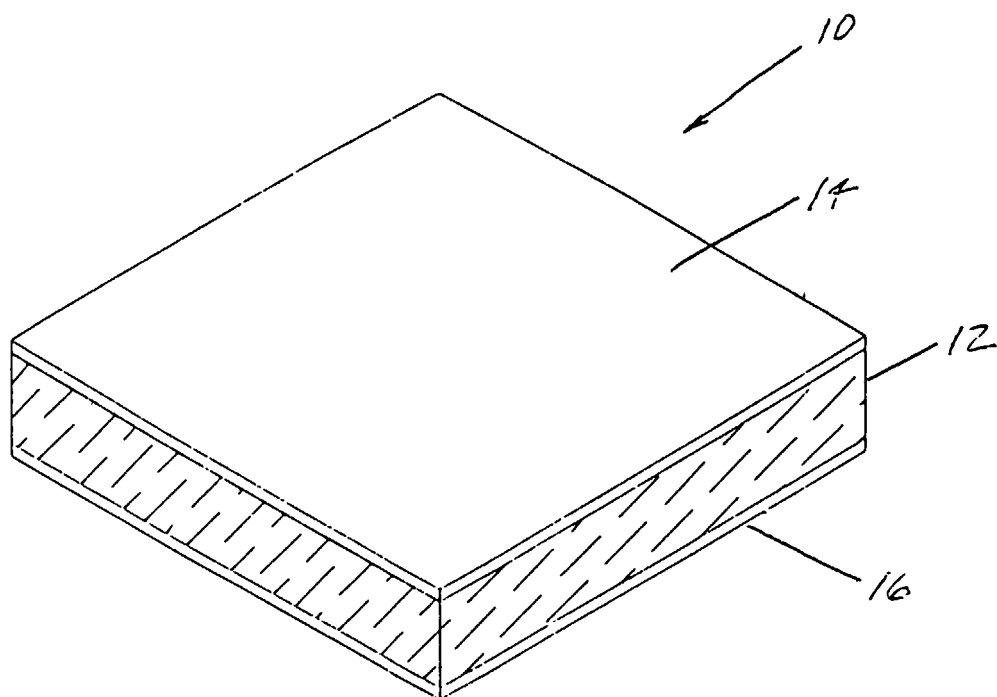


FIG. 1

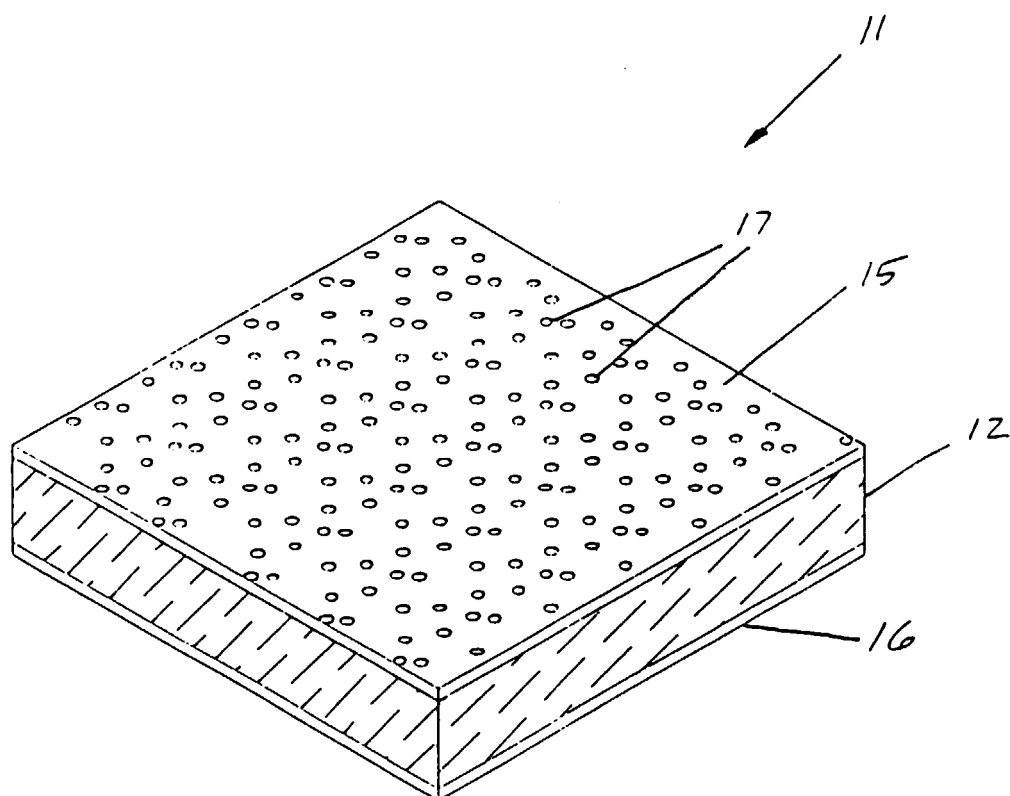


FIG. 2

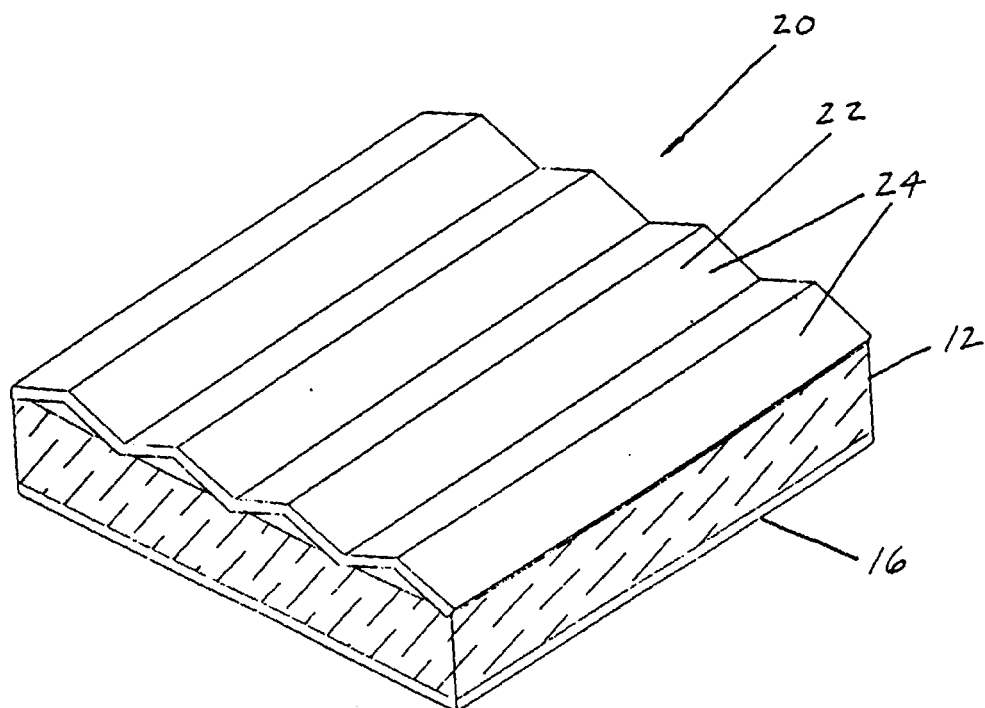


FIG. 3

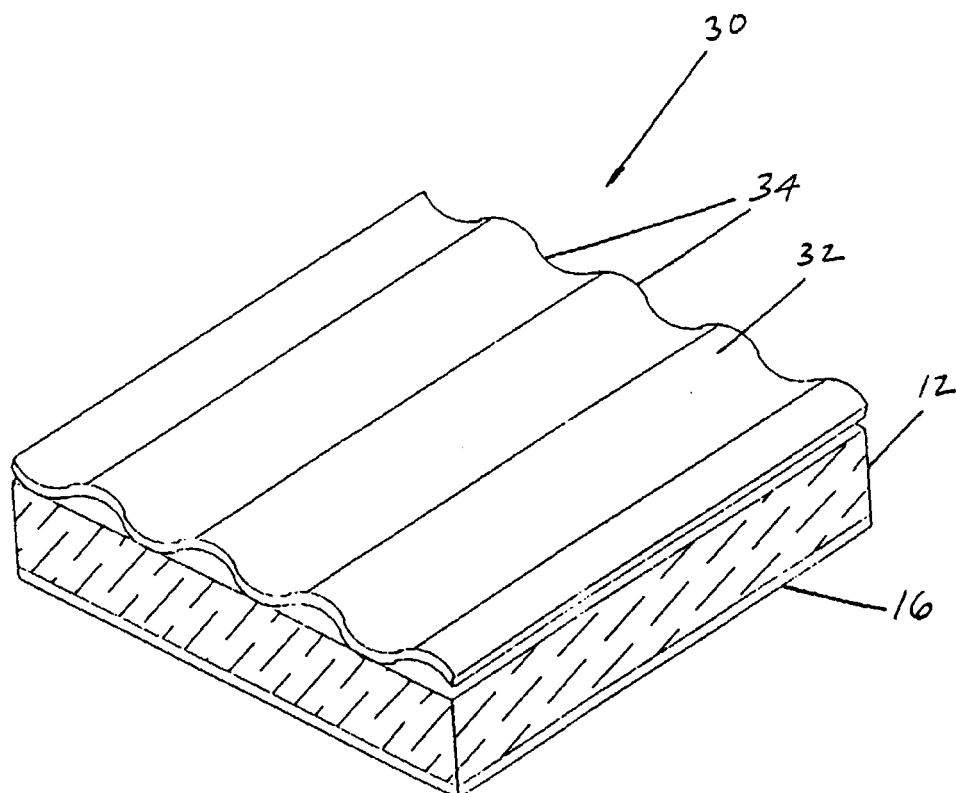


FIG. 4



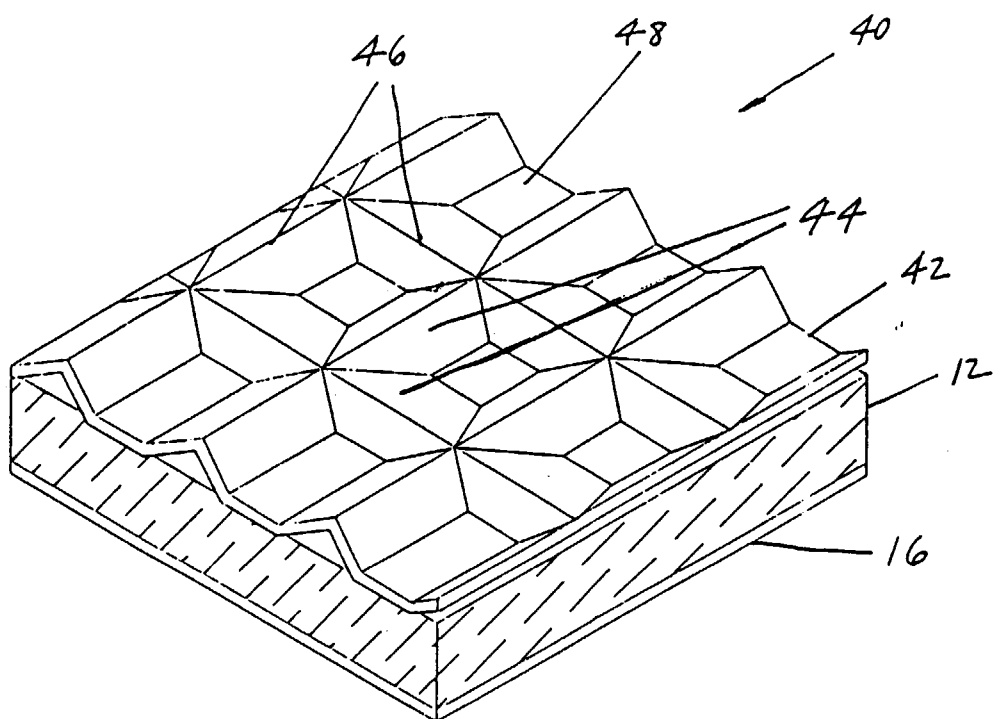


FIG. 5

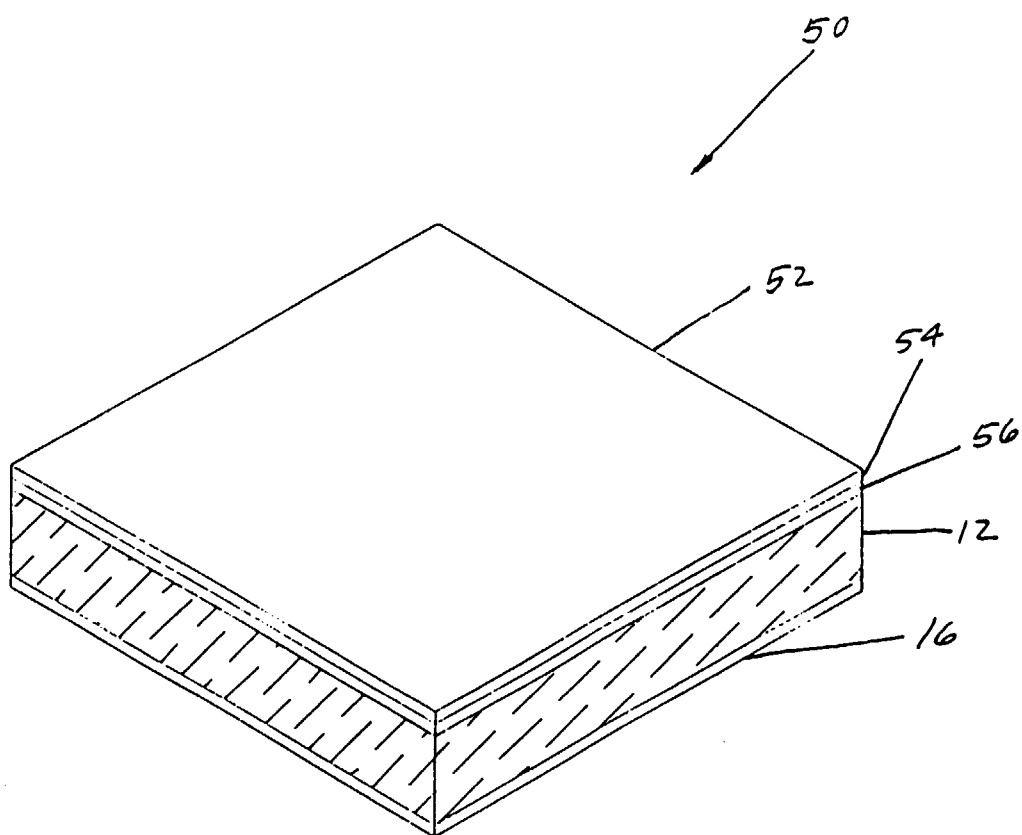


FIG. 6