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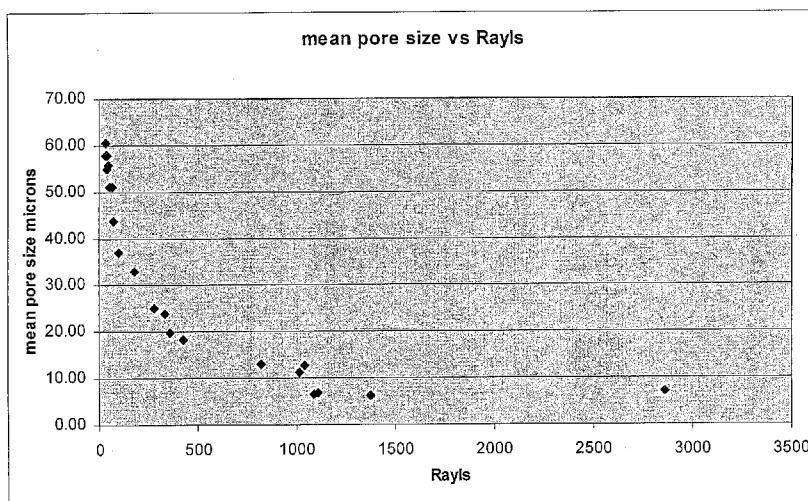


FIG. 6

(57) Abstract: A moldable acoustic facing comprises cellulosic fibers and synthetic fibers entangled together. The acoustic facing has a basis weight of from about 1.5 to about 5.0 ounces per square yard (osy), a thickness of less than about 0.050", a mean pore size of between about 8 microns and about 40 microns, and an elongation at break of at least twenty percent. The acoustic facing includes less than about five percent synthetic microfiber and has an acoustic resistance of at least about 250 Rayls.

ACOUSTICALLY TUNABLE SOUND ABSORPTION ARTICLES AND METHODS OF MAKING SAME

Related Application

[0001] This application is a continuation-in-part of U.S. Patent Application Serial No. 12/814,022, filed June 11, 2010, the disclosure of which is incorporated herein by reference in its entirety, and which itself claims priority from U.S. Provisional Patent Application No. 61/186,509, filed June 12, 2009, the disclosure of which is incorporated herein by reference in its entirety.

Field of the Invention

[0002] The present invention relates to a sound absorption material, and particularly to the use of sound absorption materials in acoustic applications such as vehicles, appliances, and buildings.

Background

[0003] Noise reduction in a wide variety of environments such as buildings, vehicles, i.e., equipment, etc., is generally considered as desirable. For example, in vehicles such as automobiles it is highly desirable to reduce the external noises, namely road noise, wind noise, engine noise, vibrations as well as internal noises through the use of various acoustic materials.

[0004] Often, acoustic engineers attempt to achieve sound attenuation by the use of various acoustic materials. For example, so-called scrim layers are often used over thick low density spacer materials and voids located in floor panels, headliners and door panels of a vehicle. One example is the use of perforated films as described in U.S. Patent No. 4,097,633. It is believed, however, that various production and quality issues are problematic in this approach. Microfiber scrims have also been proposed and used in a multilayer acoustically tuned sound absorbing composite such as described in U.S. Patent No. 6,631,785. Other examples of various scrim layers include U.S. Patent Nos. 5,186,996; 5,298,694; 5,886,306; 6,145,617; 7,310,739; and U.S. Patent Application Publication No. 2007/051800.

[0005] However, there continues to be a need for acoustic materials having improved sound absorbing properties, wherein such materials are low in thickness, low in weight, low in cost, and provide the necessary safety and sound absorption properties.

Summary

[0006] It should be appreciated that this Summary is provided to introduce a selection of concepts in a simplified form, the concepts being further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of this disclosure, nor is it intended to limit the scope of the invention.

[0007] In view of the above discussion, an acoustically tunable sound absorption facing is provided. The acoustically tunable sound absorption facing, comprises cellulosic fibers entangled together, for example, via spunlacing. Such a sound absorption facing has controllable air flow resistance. The air flow resistance translates into acoustic performance measured in Rayls. A Rayl is one of two units of acoustic impedance. When sound waves pass through any physical substance the pressure of the waves causes the particles of the substance to move. The sound impedance is the ratio between the sound pressure and the particle velocity it produces. The impedance is one Rayl if unit pressure produces unit velocity. In MKS units, 1 Rayl equals 1 pascal-second per meter ($\text{Pa}\cdot\text{s}\cdot\text{m}^{-1}$), or equivalently 1 newton-second per cubic meter ($\text{N}\cdot\text{s}\cdot\text{m}^{-3}$). In SI base units, that's $\text{kg}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$. In CGS units, 1 Rayl equals 1 dyne-second per cubic centimeter ($\text{dyn}\cdot\text{s}\cdot\text{cm}^{-3}$).

1 CGS rayl = 10 MKS Rayls.

[0008] The air flow resistance and, thus, the acoustic performance of the facing is controlled, or "tuned" by adjusting the facing construction, with regards to basis weight, cellulosic facing-to-nonwoven web ratio, and by the action of chemical and mechanical processing. Chemical finishing may include application of binder or filled binder coatings to fill in and reduce the permeability of the facing. Mechanical processing may include stretching, drawing, and/or overfeeding of the facing during the chemical finishing process, or calendaring the facing fabric after finishing to adjust the permeability. A facing, according to embodiments of the present invention, may be acoustically tuned to have air flow resistance in the range of about 245 rayls to about 2450 rayls. More preferably a facing may be tuned to have air flow resistance from about 400 rayls to about 1650 rayls, and more preferably, the facing may be tuned to have air flow resistance from about 800 rayls to about 1200 rayls.

[0009] According to some embodiments of the present invention, an acoustically tunable sound absorption facing having controllable air flow resistance comprises cellulosic fibers and a nonwoven fiber batt entangled together. The cellulosic fibers comprise between about 20 to 100 percent by weight of the sound absorption facing and the nonwoven batt comprises about 0 to 80 percent by weight of the facing. In some embodiments, the cellulosic fibers are in the form of a web or sheet. In some embodiments, the sound absorption facing has a basis weight of at least about 0.7 osy. In some embodiments, the sound absorption facing includes a flame retardant.

[0010] An acoustically tunable sound absorption facing, according to embodiments of the present invention, can be used in combination with one or more other layers or substrates to provide a sound attenuating laminate. Such a laminate can be used in a wide variety of environments including, but not limited to, vehicles. Additionally, a facing may be treated with finishes or coatings to impart color, flame resistance, resistance to oils and greases, water repellency, anti-mold and mildew, corrosion resistance, and antimicrobial properties.

[0011] An acoustically tunable sound absorption facing, according to embodiments of the present invention, may also be coated, printed, sintered, sprayed, or otherwise treated with an adhesive layer to enable bonding and molding of subsequent parts. These bonded and molded panels are typically comprised of a sound absorption facing, according to embodiments of the present invention, and a bulky, low density sound absorbing insulating panel.

[0012] Additionally, an acoustically tunable sound absorption facing, according to embodiments of the present invention, may be treated or fashioned in such a way to allow high levels of stretch when molded. This may be done by the incorporation of soft or elastomeric binders, soft or elastomeric fibers or a combination of such.

[0013] An acoustically tunable sound absorption facing, according to some embodiments of the present invention, can be used in combination with one or more other layers or substrates to provide a sound attenuating laminate. This laminate comprises a layer of the surface facing fabric of the invention laminated to a thick low density material, comprised of materials such as fiberglass batting, resinated fiberglass panels, rock wool, plastic foam, urethane foam, shoddy pad from waste fiber, polyester batting or resinated fiberfill, aerogel, closed cell foam, reticulated foam and other insulation materials known to the art. The addition of the facing fabric significantly improves the sound attenuation properties of the base absorber material, allowing for improved performance, and reduced

weight. The facing fabric may also be positioned on the top and bottom of the low density insulator to form a sandwich-type trilaminate.

[0014] Such a laminate can be used in a wide variety of environments including vehicles, appliances, buildings, homes, and office furniture (i.e. office partitions), aircraft, commercial buildings, trains and motor coaches, theaters, audio studios, home audio or theater rooms, sound insulation for noisy equipment and machines, or other applications where sound attenuation is desired.

[0015] According to some embodiments of the present invention, a moldable acoustic facing comprises cellulosic fibers (e.g., wood pulp, etc.) and synthetic fibers entangled together. The acoustic facing has a basis weight of from about 1.5 to about 5.0 ounces per square yard (osy), a thickness of less than about 0.050" as measured via ASTM D1777, a mean pore size of between about 8 microns and about 40 microns, and an elongation at break of at least twenty percent (20%) as measured via ASTM D5034. The acoustic facing comprises less than about five percent (5%) synthetic microfiber and has an acoustic resistance of at least about 250 Rayls. In some embodiments of the present invention, the cellulosic fibers comprise between about 20 to about 100 percent by weight of the acoustic facing and the nonwoven fibers comprises between about 0 to about 80 percent by weight of the acoustic facing. In some embodiments of the present invention, the cellulosic fibers are in the form of a web or paper sheet and the web or paper sheet is entangled with the nonwoven fibers. The synthetic fibers may include fibers selected from the group consisting of polypropylene, polyethylene, polyethylene terephthalate, polyester, acetate, nylon, polylactic acid (PLA), glass, viscose, tencel, rayon, and acrylic fibers, and blends thereof. Additional modification of the air flow resistance of the acoustic facing may be provided by mechanical processes (e.g., stretching, bulking, and/or calendaring) and/or chemical treatment processes (e.g., finishing, coating, and/or adhesive application).

[0016] In some embodiments of the present invention, the acoustic facing is attached to at least one additional layer to form a laminate. Exemplary additional layers include, but are not limited to, fiberglass batting, a resinated fiberglass panel, rock wool, plastic foam, urethane foam, shoddy pad from waste fiber, polyester batting or resinated fiberfill, aerogel, closed cell foam, or reticulated foam. In addition, a decorative fabric layer may also be attached to the acoustic facing.

[0017] According to some embodiments of the present invention, a moldable acoustic facing has a basis weight of from about 1.5 to about 5.0 ounces per square yard (osy), a thickness of less than about 0.050" as measured via ASTM D1777, a mean pore size of

between about 8 microns and about 40 microns, and an elongation at break of at least twenty percent (20%) as measured via ASTM D5034. The acoustic facing comprises less than about five percent (5%) synthetic microfiber and has an acoustic resistance of at least about 250 Rayls. In some embodiments, the acoustic facing comprises nonwoven fabric that may include cellulosic fibers, such as wood pulp. The cellulosic fibers may comprise between about 20 to about 100 percent by weight of the acoustic facing and synthetic fibers may comprise between about 0 to about 80 percent by weight of the acoustic facing. In some embodiments of the present invention, the cellulosic fibers are in the form of a web or paper sheet and the web or paper sheet is entangled with the nonwoven fibers. The synthetic fibers may include fibers selected from the group consisting of polypropylene, polyethylene, polyethylene terephthalate, polyester, acetate, nylon, polylactic acid (PLA), glass, viscose, tencel, rayon, and acrylic fibers, and blends thereof. Additional modification of the air flow resistance of the acoustic facing may be provided by mechanical processes (e.g., stretching, bulking, and/or calendaring) and/or chemical treatment processes (e.g., finishing, coating, and/or adhesive application).

[0018] In some embodiments of the present invention, the acoustic facing is attached to at least one additional layer to form a laminate. Exemplary additional layers include, but are not limited to, fiberglass batting, a resinated fiberglass panel, rock wool, plastic foam, urethane foam, shoddy pad from waste fiber, polyester batting or resinated fiberfill, aerogel, closed cell foam, or reticulated foam. In addition, a decorative fabric layer may also be attached to the acoustic facing.

[0019] According to other embodiments of the present invention, a sound absorption laminate includes first and second acoustic facings, and a low density layer of material sandwiched between the first and second acoustic facings. Each facing is a moldable fabric having a basis weight of from about 1.5 to 5.0 ounces per square yard (osy), a thickness of less than about 0.050" as measured via ASTM D1777, a mean pore size of between about 8 microns and about 40 microns, and an elongation at break of at least twenty percent (20%) as measured via ASTM D5034. The fabric of each facing includes less than about five percent (5%) synthetic microfiber and has an acoustic resistance of at least about 250 Rayls. The low density layer of material may include a fiberglass batting, a resinated fiberglass panel, rock wool, plastic foam, urethane foam, shoddy pad from waste fiber, polyester batting or resinated fiberfill, aerogel, closed cell foam, or reticulated foam.

[0020] According to other embodiments of the present invention, a sound absorption article includes a facing having a finish coating for providing one or more additional

functional properties (e.g., flame retardancy, adhesive properties, crock resistance, grab tensile, tear strength, color, microbial resistance, electrical conductivity, thermal conductivity, opacity, controllable modulus, water repellency, corrosion resistance, and controllable surface texture) to the facing, and a low density layer of material laminated to the facing. The facing is a moldable fabric having a basis weight of from about 1.5 to 5.0 ounces per square yard (osy), a thickness of less than about 0.050" as measured via ASTM D1777, a mean pore size of between about 8 microns and about 40 microns, and an elongation at break of at least twenty percent (20%) as measured via ASTM D5034. The fabric comprises less than about five percent (5%) synthetic microfiber and has an acoustic resistance of at least about 250 Rayls;

[0021] According to other embodiments of the present invention, a method of making an acoustically tuned facing includes preparing a moldable acoustic fabric and tuning the fabric to have an acoustic resistance of at least about 250 Rayls by applying a chemical finish to the fabric and/or subjecting the fabric to one or more mechanical processes (e.g., stretching, bulking, calendaring, or a combination thereof). The moldable acoustic fabric has a basis weight of from about 1.5 to 5.0 ounces per square yard (osy), a thickness of less than about 0.050" as measured via ASTM D1777, a mean pore size of between about 8 microns and about 40 microns, and an elongation at break of at least twenty percent (20%) as measured via ASTM D5034. Furthermore, the moldable acoustic fabric comprises less than about five percent (5%) synthetic microfiber.

[0022] In some embodiments, the method further includes laminating at least one additional layer to the fabric. Exemplary additional layers include, but are not limited to, fiberglass batting, a resinated fiberglass panel, rock wool, plastic foam, urethane foam, shoddy pad from waste fiber, polyester batting or resinated fiberfill, aerogel, closed cell foam, or reticulated foam. In addition, the at least one additional layer may be a decorative fabric layer.

[0023] It is noted that aspects of the invention described with respect to one embodiment may be incorporated in a different embodiment although not specifically described relative thereto. That is, all embodiments and/or features of any embodiment can be combined in any way and/or combination. Applicant reserves the right to change any originally filed claim or file any new claim accordingly, including the right to be able to amend any originally filed claim to depend from and/or incorporate any feature of any other claim although not originally claimed in that manner. These and other objects and/or aspects of the present invention are explained in detail below.

Brief Description of the Drawings

[0024] Figure 1 is the measured influence of various developmental facings measured in the impedance tube.

[0025] Figure 2 is a predicted normal incidence sound absorption graph using ESI Nova modeling software.

[0026] Figure 3 is a predicted alpha cabin sound absorption graph using ESI modeling software.

[0027] Figure 4 is a table of properties of various facings, according to some embodiments of the present invention.

[0028] Figure 5 is a graph of air permeability versus mean pore size for various facings, according to some embodiments of the present invention.

[0029] Figure 6 is a graph of mean pore size versus Rayls for various facings, according to some embodiments of the present invention.

Detailed Description

[0030] The present invention now is described more fully hereinafter with reference to the accompanying drawings, in which some embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art.

[0031] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, steps, operations, elements, components, and/or groups thereof. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items and may be abbreviated as "/".

[0032] The terms "facing," "facing layer," and "facing fabric" are interchangeable as used herein and are defined as a layer of material that can be attached to a surface of another object or material. A facing layer can be attached to a surface of another object or material in

various ways including, but not limited to, adhesive bonding, thermal bonding, point bonding, pressure bonding, extrusion coating, or ultrasonic bonding.

[0033] The term "laminate" as used herein refers to a composite structure of two or more material layers that have been adhered through a bonding step, such as through adhesive bonding, thermal bonding, point bonding, pressure bonding, extrusion coating, or ultrasonic bonding.

[0034] The term "machine direction" or MD refers to the direction along the length of a fabric in the direction in which it is produced.

[0035] The terms "cross machine direction," "cross directional," or CD mean the direction across the width of fabric, i.e. a direction generally perpendicular to the MD.

[0036] The terms "nonwoven" and "nonwoven web" refer to materials and webs of material having a structure of individual fibers or filaments which are interlaid, but not in an identifiable manner as in a knitted fabric. The terms "fiber" and "filament" are used herein interchangeably. Nonwoven fabrics or webs may be formed from many processes including, but not limited to, meltblowing, spunbonding, air laying processes, etc.

[0037] Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the specification and relevant art and should not be interpreted in an idealized or overly formal sense unless expressly so defined herein. Well-known functions or constructions may not be described in detail for brevity and/or clarity.

[0038] In some embodiments, an acoustically tunable sound absorption facing is provided by a cellulosic web or sheet and a nonwoven web entangled together. The cellulosic web or sheet consists of a wet-laid or paper like sheet of cellulosic fiber. While wood fiber is preferred, other types of cellulosic fiber that can be wet-laid into a paper sheet could be used as the precursor cellulosic web. Additionally, minor amounts, not to exceed 49% of the cellulosic web could be comprised of synthetic fibers. Useful cellulosic fibers include wood fibers (pulp) such as bleached Kraft, softwood or hardwood, high-yield wood fibers, cotton, viscose, and other fibers suitable for making into a paper sheet. Other natural fibers include bagasse, milkweed, wheat straw, kenaf, jute, hemp, bamboo, cotton, and these natural fibers may be blended with the cellulosic fibers. Synthetic fibers that are prepared in very short fiber length may be formed into a wet-laid paper sheet. These fibers may be

polyester, nylon, olefin, cellulose acetate, silk, wool, and other fibers known to the art. A preferred selection of wood fibers that provide the desired air flow resistance in the final cellulosic sheet may be employed for this facing; are red cedar and spruce pulps.

[0039] The nonwoven web portion may contain randomly oriented fibers or substantially aligned fibers. Exemplary fibers include, but are not limited to, polypropylene, polyethylene, polyethylene terephthalate, polyester, acetate, nylon, polylactic acid (PLA), glass, viscose and acrylic fibers, and blends thereof. Alternatively, performance fibers such as Nomex or Kevlar (DuPont), Kermel (Rhone Poulenc), polybenzimidazole (PBI – Hoechst), Basofil (BASF), polyetheretherketone (PEEK – Zyex Ltd.), Visil (Kuitu Finland Oy), Ultem, Lexan or Valox (GE Plastics) fibers may be used. The staple fiber batt may be made using 1.5 denier 1.5 inch long polyester drawn and crimped fibers which are known to spunlace well. However, other length and denier fibers including microfiber and splittable staple fibers may also be used for the nonwoven portion of the sound absorption facing.

[0040] The basis weight for the facing fabric before finishing is from about 0.7 to about 5.0 ounces per square yard (osy). Typically, the facing comprises 20-100 percent by weight cellulosic fibers by weight and 0-80 percent by weight other fibers.

[0041] As mentioned above, after the sound absorption facing has been formed and dried, it may be used without additional processing. If the initial air flow resistance of a given fabric is not in the desired range, the sound absorption facing can be further modified by finishing and/or calendaring. Stretching, bulking, drawing, drying and curing of the facing are additional steps that generally occur during the finishing or coating process. These processes are to modify and adjust the permeability and sound attenuating properties of the sound absorption facing so as to tune the sound attenuation properties. Additionally, the use of the scrim fabric of the invention on the face of a bulky and heavy sound absorber panel, allows reduction in the weight and bulk, without a loss of performance.

[0042] Acceptable levels of stretch of acoustic facings, according to embodiments of the present invention are shown in Table 1 below. The data in Table 1 was obtained in accordance with ASTM D5034.

Table 1**Acoustic Facing -**

Style #	MD Elongation (%)	CD Elongation (%)	MD Modulus at 10%	Description
Industry Incumbent	17.3	33.7	11.4	1.7 osy facing (non PFG)
6075-50001	22.4	48.4	22.4	08851 stretched 155-180"
6075-51001	24.5	53.23	18.67	6075-50001 calendered
6075-50003	23.7	88.3	27.7	08851 necked down 155-144" (450F)
6075-50006	23	86.1	27	8851 necked down 155-144" (300F)
6075-54006	22.1	79.4	30.1	6075-50006 coated with reactive adhesive
6186-50011	35.4	61.5	8.6	08851 stretched 155-177"
6186-52010	33.4	56.9	12.7	6186-50011 coated with PET adh on Line 8
6186-50012	36.4	56.7	7.5	08851 stretched 155-180"
6186-50020	29.5	96	15.7	0881 necked down 155-146"
6300-50003	28.1	138.1	19.3	00697 finished on Frame #1 (no stretch)
6300-51003	28.7	157.53	13.43	6300-50003 calendered (CAL # - 250 F)
6300-52103	25	135.6	23.3	6300-51003 coated with PET adh on Line 8
Min	17.3	33.7	7.5	
Max	36.4	157.53	30.1	

As indicated above in Table 1, an elongation at break of at least 17% is necessary for an acoustic facing to be moldable, according to embodiments of the present invention.

[0043] The chemical finishing of the facing comprises application of chemistry that will form film structure or fill in the structure of the facing thereby reducing the air permeability, and increasing the sound attenuation properties of the product. Emulsion and solution binders, adhesives, polymer dispersions, and thickeners may be used to reduce the permeability of the sheet. Additionally, the binder solutions may have added filler materials such as clay, talc, glass beads, ceramic beads and particles, graphite, calcium carbonate, barium sulfate, vermiculite, hydrated alumina, titanium dioxide, expandable fillers, expandable microspheres, swellable fillers, and other particulate filler materials to assist in decreasing the permeability of the sheet. Auxiliary chemicals such as corrosion inhibitors, flame retardants, oil and water repellents, pigments and colors, antimicrobial agents, and adhesive promoters may be added to enhance the properties of the sheet for a particular end

use. For example, an acoustic panel for use in an automobile engine compartment would need to be both flame retardant and oil resistant.

[0044] Other types of finishing application equipment may be used to accomplish the addition of the chemical finish to the facing, including printing, paste coating, kiss coating, spray, roller coating, gravure, slot coating, and other application methods known to the art.

[0045] Various flame retardants may also be useful for finishing the sound absorption facing in order to impart flame retardant properties, low smoke generation and heat resistant properties and to increase the density or modify the air flow resistance of the facing. Flame retardants which are useful for this invention include durable, semi-durable and nondurable flame retardants, organic and inorganic flame retardants and combinations thereof.

Furthermore, functional fillers such as alumina trihydrate, ammonium polyphosphate, compounds containing alkali and alkaline earth metals, borates, ammonium salts, nitrogen containing compounds, phosphates, phosphonates, halogens and sulfamates are useful for finishing and coating the facing. Other types of flame retardants which are of utility in this application include intumescence systems, vapor phase flame retardants and systems, endothermic flame retardants and combinations thereof. The list of possible flame retardants for this application is vast and will be obvious to those skilled in the art of finishing and coating fabrics.

[0046] Any water based emulsion or dispersion commonly known as a binder or latex may also be used to modify the air flow resistance of the sound absorption facing and to impart additional functional properties to the facing. Acrylic binders, vinyl acrylic binders, vinyl acetate binders, styrene containing binders, butyl containing binders, starch binders, polyurethane binders, and polyvinylalcohol containing binders are examples of binders that find utility in coating and finishing the facing. The binders may be film forming so as to reduce the air flow resistance of the sound absorption facing. The binders may also be loaded with a filler so as to reduce the air flow resistance of the sound absorption facing. Also, the binders may be salt tolerant so that they can be used in conjunction with ionic flame retardants. The use of thermoplastic binders can provide adhesive properties to the sound absorption facing if the binder is on the surface of the facing and the facing is subsequently reheated to bond to another surface. Binders may also be thermoset to limit the degree of crushing during the calendering process, thereby allowing for a controllable and small reduction in air flow resistance. On the other hand, thermoplastic binders may be utilized to cause a large reduction in air flow resistance during the calendering process. Other properties that the binder may impart include, but are not limited to, improved crock resistance,

increased grab tensile and greater tear strength. Selected binders may be applied to the sound absorption facing to modify its stiffness and flexibility and to cause the facing to retain its shape if it is post molded or "B staged."

[0047] The concentration of binder in a pad finishing formulation is generally between 0 percent and 25 percent. When a foam finishing or coating process is utilized, binders may comprise between 0 percent and 100 percent of the finish formulation. In similar fashion flame retardants may comprise between 0 percent and 100 percent of a finishing formulation depending on application method and the properties that are being sought through finishing. Pigment dispersions, water repellents, waxes, lubricants, dyes, antimicrobials, defoamers, profoamers, corrosion inhibitors, antimicrobials, thickening agents, wetting agents, fillers, and other coating additives are useful in the present invention.

[0048] Additionally, the chemical modification of the scrim can be accomplished through solvent based, 100% solids based, powder application, hot melt application or other chemistry application methods known to the art.

[0049] The sound absorption facing may be used as a decorative layer, e.g., a fabric layer, or it may be covered with other layers to improve the aesthetic properties. In order to make bonding to high loft layers or decorative layers easier, it is possible to print or coat an adhesive pattern onto the facing which does not materially change the air flow resistance thereof. The adhesive can be applied as a hot melt using a pattern engraved in a gravure roll, powder coating, adhesive web, adhesive film or net, by screen printing or foam coating a pattern of compounded powdered adhesive or adhesive onto the facing, or by spraying adhesive onto the facing. The adhesive is selected according to the temperature desired for thermally reactivating the adhesive, according to the material that will be mated with the sound absorption facing and according to other factors such as the open time of the adhesive, the temperature capabilities of the processing equipment, adhesive viscosity, melt-flow index, and the strength and esthetic qualities of the bond. The array of thermally reactivateable adhesives, application equipment, and application techniques is vast; however, someone trained in the art can quickly arrive at a suitable system for this application. The types of adhesives that have been used to good effect include thermoplastic and thermoset adhesives such as polyester based adhesives, polyamide, urethane, and olefinic adhesives. When thermoset adhesives are applied to the facing it is important not to keep the adhesive below the cross linking temperature when it is applied. The adhesive may be used to adjust the air flow resistance of the facing.

[0050] Furthermore, continuous or perforated films or nets or other nonwoven material comprising low density polyethylene, high density polyethylene, ethylene vinyl acetate, polypropylene, maleic anhydride, or any olefinic materials manufacture using either the Ziegler Natta or a transition metal catalyst or any blends of these materials may be tacked to the surface of the air flow resistant scrim. These films, nets, and nonwoven materials are attached to the scrim with the knowledge that they will melt into adhesive islands during subsequent processes and will have minimal effect on the final air flow resistance of the acoustic composite.

[0051] In the course of investigating the properties of thin acoustic facings, wherein the acoustic tuning of the facing can be controlled, according to some embodiments of the present invention, Applicants have unexpectedly discovered that the mean pore size of the facing material directly relates to the permeability and air flow resistance, for example, as measured in Rayls. Experimental testing of mean pore size was performed on various acoustic facings, according to embodiments of the present invention, via a Capillary Flow Porometer CFP-1100-AEX manufactured by PMI, Inc. The pore size determination was made for each acoustic facing using the following methodology:

Standard Test Method for Pore Size (Porometer)

1. Scope

1.1 This test method is used to determine the pore size characteristics of non-woven and woven fabrics in a specific unit of measurement. This method ensures that finished goods meet specification or provides useful information regarding a sample.

2. Referenced Documents

2.1 ASTM E 1294-89, F 316

3. Summary of Test Method

3.1 A sample is wetted with a low surface tension and vapor pressure liquid and is placed in a chamber. An increasing air pressure is applied and as successively smaller pores empty, the airflow is recorded as a function of pressure. The maximum and minimum pore sizes are obtained and compared with the flow rate against applied pressure for a dry sample. The pore size distribution is thereby obtained in microns.

4. Apparatus

4.1 PMI Porometer (Note: see the Standard Operating Procedure for the Porometer for specifics on calibration and maintenance.)

4.2 Porewick test solution

4.3 watch glass, tweezers, clicker / Hytronic press, 37mm diameter cutting die

5. Hazards / Safety

5.1 Ensure proper placement of hands when using the clicker press

5.2 Avoid chemical contact with eyes.

6. Conditioning

6.1 Samples do not require conditioning prior to testing.

7. Sampling

7.1 Refer to Standard Guidelines for Specimen Sampling. Generally, a side center side sampling plan is used.

8. Procedure

8.1 Cut 37mm diameter samples for testing. Pour very small amount of Porewick solution into a watch glass. Place a sample to be tested into the solution.

8.2 Remove cover of test chamber, then remove the cylinder and top plate. Be sure to remove any samples that have already been tested. Be sure that the "O" ring is visible on the bottom plate.

8.3 Remove sample from solution with tweezers and place on the center of the bottom plate in the chamber.

Place the top plate ("O" ring side down) over the sample. Replace the cylinder ("O" ring and screen side down) over the top plate.

8.3 Double click on Capwin shortcut icon on computer. Click on group and select QC or other as needed. Click on Execute, then Auto-test.

8.4 Double click on output file name or choose a style folder, and enter required information.

8.5 Enter Operator, then Continue. Click on Start Test, continue, then OK to initiate test.

8.6 The computer will signal the end of the test with a message box. Click on OK and remove the sample from the chamber.

8.7 Back on the home page, click on Report, then Execute, then Begin. Follow further instructions to print summary sheet. After results are printed, click Continue, then Close to return to the home page.

9. Report

9.1 Report the average pore size in microns, or submit the Summary sheet.

Data for various acoustic facings, according to embodiments of the present invention, is contained in the table illustrated in Figure 4. The relationship between the mean pore size and air flow resistance, as measured in Rayls, for the various acoustic facings in the table of Figure 4 is shown in the Figures 5 and 6.

[0052] Applicants have unexpectedly discovered acoustic materials that are acceptable for a moldable sound absorption panel facing, that are extensible enough be molded, that are thin, that are not heavy in basis weight, and have the proper pore size to deliver the permeability and acoustic resistance. A useful range of average pore size is from about 8 to about 40 microns.

[0053] Some of the materials listed in the above table, achieve the proper pore size through the use of microfiber. Synthetic microfibers are generally defined as fibers from

about 0.1 to 10 microns in diameter. Microfiber can be produced by splitting larger fibers as in the Evolon® brand products from Freudenberg Nonwovens or by creating microfiber through meltblown processes as described in U.S. Patent No. 5,178,932 to Perkins, or by flash spinning fiber as in the Tyvek® brand products from DuPont, or by producing multi component fiber, and dissolving away some of the fiber mass to leave microfibers. The use of microfiber based acoustic facing is well known.

[0054] However, for products that do not contain microfiber, or contain ineffective amounts of microfiber, Applicants have determined that the pore size and the acoustic properties are lacking in performance. Acoustic facings, according to embodiments of the present invention have a pore size of from about 8 to 40 microns, without the use of microfiber. Applicants have also found that one way of developing these acoustic facings is to prepare a nonwoven fabric that contains an effective amount of cellulose fibers. Cellulose fibers are flat and can produce effective pore size structures at useful basis weights.

However, embodiments of the present invention are not limited to the use of cellulosic fibers.

[0055] The following examples are merely illustrative of the invention, and are not limiting thereon.

Example 1

[0056] We loaded a 155" wide roll of wood pulp / polyester spunlaced fabric (i.e., facing), known by the brand name Sontara Style 8851 onto a creel stand in front of a finishing frame. This Sontara fabric has an average air flow resistance of 496 Rayls. We padded the 2.1 ounce per square yard fabric, through a dip and nip style pad bath at 70 pounds per square inch to achieve a wet pick up of around 130 percent of the following formulation:

Mix Formula: To 50 gallons of water we added 20 lbs of Suncryl CP-75 (Omnova), a vinyl acrylic copolymer dispersion), while stirring. We continued stirring and added 10 lbs of S-Inmont Black 6612 (BASF Corporation), a carbon black pigment dispersion, and then 210 lbs of Spartan 590FR (Spartan Flame Retardants, Inc), an ammonium phosphate type flame retardant. We increased the volume to 100 gallons of water while stirring to complete the mix.

[0057] After the pad process the fabric is pinned onto a pin tenter frame, stretched to width and dried as follows:

1. unstretched i.e. 0 percent resulting in an air flow resistance of 700 Rayls, a basis weight of 2.7 osy, and a SE rating for MVSS 302 flammability.

2. stretched to 159 inches 2.58 percent resulting in an air flow resistance of 578 Rayls, a basis weight of 2.6 osy, and a SE rating for MVSS 302 flammability.
3. stretched to 168 inches 8.38 percent resulting in an air flow resistance of 458 Rayls, a basis weight of 2.6 osy, and a SE rating for MVSS 302 flammability.

[0058] In another experiment we used the Sontara Style 8851 fabric (i.e., facing) mentioned above and padded the following mix onto the fabric at 70 psi to achieve a wet pick up of around 130 percent of the following mix:

Mix Formula: To 50 gallons of 30°C water we added 12 lbs of Lumacron Black SEF 300 percent (Dohmen), a disperse dye, while stirring. We continued stirring and added 240 lbs of Spartan 987FR (Spartan Flame Retardants, Inc), a non-durable, nonfogging ionic flame retardant. Then we increased the volume to 100 gallons of water while stirring to complete the mix.

[0059] After the pad process the fabric was pinned onto a pin tenter and stretched to the 174" 12.2 percent and dried resulting in an air flow resistance of 386 Rayls, a SE rating for MVSS 302 flammability, and a basis weight of 2.4 osy.

Example 2

[0060] We loaded a 154" wide roll of blue wood pulp / polyester spunlaced fabric (i.e., facing), known by the brand name Sontara Style 9918 onto a creel stand in front of a finishing frame. This Sontara fabric has an average air flow resistance of 449 Rayls. We padded the 2.5 osy fabric, through a dip and nip style pad bath at 90 psi to achieve a wet pick up of around 139 percent using undiluted Spartan 987FR (Spartan Flame Retardants, Inc).

[0061] After the pad process the fabric was pinned onto a pin tenter and stretched from 155" to 166". The stretched fabric had an air flow resistance of 740 Rayls, a SE rating for MVSS 302 flammability, and a basis weight of 4.3 osy.

[0062] In a similar example we used Sontara 8851 and undiluted Spartan 987FR padded at 90 psi and necked the fabric from 155" down to 146". This resulted in a fabric with an average air flow resistance of 839 Rayls, a SE rating for MVSS 302 flammability, and a basis weight of 3.5 osy.

Example 3

[0063] We followed the methodology of the above experiment with a few changes. The 100 gallon pad bath mix was made to incorporate the following ingredients: 25 pounds of Amgard CT (Rhodia Corporation) a durable cyclic phosphonate, 33.5 pounds of Spartan

880FR (Spartan Flame Retardants, Inc), 70 pounds of Inmont S Black 6612 (BASF Corporation), and 125 pounds of Phobol 8315 (Ciba Corporation) a fluorocarbon based water repellent.

[0064] In this example we used Sontara 8851 and a pad pressure of 90 psi and necked the fabric down from 155" to 143". This resulted in a fabric with an average air flow resistance of 839 Rayls, a SE rating for MVSS 302 flammability, and a basis weight of 2.7 osy.

Example 4

[0065] We calendared fabrics (i.e., facings) from the examples above using a hot oil calendar having a composite roll over a steel roll running at 40 ypm, 2000 psi and 200°F.

1. The average air flow resistance of the 700 Rayl fabric, increased to 2048 Rayls (Dev. Facing A);
2. The average air flow resistance of the 578 Rayl fabric, increased to 1687 Rayls(Dev. Facing B);
3. The average air flow resistance of the 458 Rayl fabric, increased to 1629 Rayls (Dev. Facing C);
4. The average air flow resistance of the 386 Rayl fabric (processed at 1600 psi rather than 2000 psi), increased to 1143 Rayls (Dev. Facing D).

The normal incidence sound absorption is shown in Figure 1.

Examples 5-7

[0066] We loaded a 155" wide roll of wood pulp/polyester spunlaced fabric (i.e., facing) (Sontara Style 8851) onto a creel stand in front of a finishing frame. This Sontara fabric has an average air flow resistance of 496 Rayls. We padded the 2.1 ounce per square yard fabric, through a dip and nip style pad bath at 70 pounds per square inch to achieve a wet pick up of around 130 percent of a formulation:

Mix Formula: To 50 gallons of water we added 70 lbs of Inmont S Black 6612 (BASF Corporation, a carbon black dispersion) while stirring. We continued stirring and added 70 lbs of acrylic latex dispersion (Rhoplex TR-25 (Dow Chemical Corporation). The volume of water was increased to 100 gallons of water while stirring to complete the mix. After the pad process the fabric was pinned onto a pin tenter and necked down in the machine direction from 155" to 143". The necked down fabric had an air flow resistance of 728 Rayls and a

basis weight of 2.5 osy. This cellulosic fabric was combined with a nonwoven batt based on fiberglass fibers as follows:

<u>Example</u>	<u>Density of Nonwoven Fiber Batt (lbs/ft³)</u>
5	2.0
6	1.5
7	1.25

Example 8

[0067] An all fiber nonwoven, with viscose (cellulose) fiber blended with polyester fiber, was prepared. A 63" wide roll of a 78 gsm 70/30 Viscose / Polyester spunlaced fabric from Alhstrom Greenbay was loaded onto a creel stand in front of a finishing frame. This fabric has an average air flow resistance of 90 Rayls. We pad finished the 78 gsm fabric in a similar process described in the above examples with a black, fire retardant, water repellent, and corrosion resistant finish.

[0068] After the pad process the fabric is pinned onto a pin tenter frame, where the fabric can be stretched or necked down. In this example the product was unstretched (63" in, 63" out), which resulted in a basis weight of 85 gsm, an air flow resistance of 93 Rayls, and a SE rating for MVSS 302 flammability. The product was further calendered at a temperature of 250 F and pressure of 2000 psi, which resulted in a reduction of air flow resistance to 278 Rayls.

Comparative Example 1

[0069] A nonwoven fiberglass batt having a density of 2.0 lbs/ft³ was combined with a 1.7 ounce/square yard, 100% polyester thermal bonded nonwoven fabric, with a coating of low density polyethylene adhesive, from Textil Gruppe Hof, with a permeability of 50-100 rayls (average 60 rayls).

[0070] Figure 2 illustrates the predicted normal incidence sound absorption of Examples 5-7 and the Comparative Example 1. Figure 3 measures the predicted alpha cabin sound absorption of Examples 5-7. This demonstrates that a facing, according to embodiments of the present invention, can provide acceptable sound absorption properties without requiring higher density and more expensive materials as the nonwoven batt.

All Fiber Example 1

[0071] A 63" wide roll of a 78 gsm 70/30 Viscose / Polyester spunlaced fabric was loaded onto a creel stand in front of a finishing frame. This fabric has an average air flow resistance of 90 Rayls. We pad finished the 78 gsm fabric in a similar process described in the above examples with a black, fire retardant, water repellent, and corrosion resistant finish.

[0072] After the pad process the fabric is pinned onto a pin tenter frame, where the fabric can be stretched or necked down. In this example the product was unstretched (63" in, 63" out), which resulted in a basis weight of 85 gsm, an air flow resistance of 93 Rayls, and a SE rating for MVSS 302 flammability. The product was further calendered at a temperature of 250 F and pressure of 2000 psi, which resulted in a reduction of air flow resistance to 278 Rayls.

All Fiber Example 2

[0073] A 58" wide roll of a 78 gsm 70/30 Viscose / Polyester spunlaced fabric was loaded onto a creel stand in front of a finishing frame. This fabric has an average air flow resistance of 90 Rayls. We pad finished the 78 gsm fabric in a similar process described in the above examples with a black, fire retardant, and water repellent.

[0074] After the pad process the fabric is pinned onto a pin tenter frame where the fabric width can be adjusted. The above finished fabric was processed at two different widths described below.

- Stretched slightly (58" to 61"), which resulted in a finished basis weight of 98 gsm, an air flow resistance of 126 Rayls, and a SE rating for MVSS 302 flammability after finishing.
- Necked down (58" to 46"), which resulted in a finished basis weight of 124 gsm, an air flow resistance of 218 Rayls, and a SE rating for MVSS 302 flammability after finishing.

The above material was further processed using a calendaring process at 2000 psi with the varied temperatures.

- The slightly stretched material was calendared at 200° F, which resulted in an air resistance of 310 Rayls.
- The necked down material was calendared at various temperatures summarized below.

- 100° F, which resulted in an air resistance of 436 Rayls
- 150° F, which resulted in an air resistance of 607 Rayls
- 200° F, which resulted in an air resistance of 908 Rayls

[0075] Having thus described certain embodiments of the present invention, it is to be understood that the invention defined by the appended claims is not to be limited by particular details set forth in the above description as many apparent variations thereof are possible without departing from the spirit or scope thereof as hereinafter claimed.

What is Claimed:

1. A moldable acoustic facing, comprising cellulosic fibers and a nonwoven batt entangled together, wherein the acoustic facing has a basis weight of from about 1.5 to about 5.0 ounces per square yard (osy), a thickness of less than about 0.050" as measured via ASTM D1777, a mean pore size of between about 8 microns and about 40 microns, and an elongation at break of at least twenty percent (20%) as measured via ASTM D5034, wherein the acoustic facing comprises less than about five percent (5%) synthetic microfiber, and wherein the acoustic facing has an acoustic resistance of at least about 250 Rayls.
2. The acoustic facing of Claim 1, wherein the cellulosic fibers comprise between about 20 to about 100 percent by weight of the acoustic facing and the nonwoven batt comprises between about 0 to about 80 percent by weight of the acoustic facing.
3. The acoustic facing of Claim 1, wherein the cellulosic fibers are in the form of a web or paper sheet.
4. The acoustic facing of Claim 1, wherein the cellulosic fibers comprise wood pulp.
5. The acoustic facing of Claim 1, wherein the nonwoven fabric is a spunlaced fabric comprising a paper sheet entangled with synthetic fibers.
6. The acoustic facing of Claim 1, wherein additional modification of the air flow resistance of the acoustic facing is provided by one or more processes selected from the group consisting of mechanical processes and chemical treatment processes.
7. The acoustic facing of Claim 6, wherein mechanical processes include stretching, bulking, and/or calendaring.
8. The acoustic facing of Claim 6, wherein chemical treatment processes includes finishing, coating, and/or adhesive application.

9. The acoustic facing of Claim 1, wherein the nonwoven batt comprises fibers selected from the group consisting of polypropylene, polyethylene, polyethylene terephthalate, polyester, acetate, nylon, polylactic acid (PLA), glass, viscose, tencel, rayon, and acrylic fibers, and blends thereof.

10. A laminate comprising the acoustic facing of Claim 1 and at least one additional layer laminated thereto.

11. The laminate of Claim 9, wherein the at least one additional layer is selected from the group consisting of: fiberglass batting, a resinated fiberglass panel, rock wool, plastic foam, urethane foam, shoddy pad from waste fiber, polyester batting or resinated fiberfill, aerogel, closed cell foam, or reticulated foam.

12. The laminate of Claim 9, wherein the at least one additional layer is a decorative fabric layer.

13. A moldable acoustic facing having a basis weight of from about 1.5 to about 5.0 ounces per square yard (osy), a thickness of less than about 0.050" as measured via ASTM D1777, a mean pore size of between about 8 microns and about 40 microns, and an elongation at break of at least twenty percent (20%) as measured via ASTM D5034, wherein the acoustic facing comprises less than about five percent (5%) synthetic microfiber, and wherein the acoustic facing has an acoustic resistance of at least about 250 Rayls.

14. The acoustic facing of Claim 13, wherein the acoustic facing comprises nonwoven fabric.

15. The acoustic facing of Claim 14, wherein the acoustic facing comprises cellulosic fibers.

16. The acoustic facing of Claim 15, wherein the cellulosic fibers comprise wood pulp.

17. The acoustic facing of Claim 15, wherein the acoustic facing comprises a paper sheet spunlaced with fibers.

18. The acoustic facing of Claim 15, wherein the cellulosic fibers comprise between about 20 to about 100 percent by weight of the acoustic facing and synthetic fibers comprise between about 0 to about 80 percent by weight of the acoustic facing.

19. The acoustic facing of Claim 15, wherein the cellulosic fibers are in the form of a web or paper sheet.

20. The acoustic facing of Claim 14, wherein the nonwoven fabric is a spunlaced fabric comprising a paper sheet entangled with synthetic fibers.

21. The acoustic facing of Claim 13, wherein additional modification of the air flow resistance of the acoustic facing is provided by one or more processes selected from the group consisting of mechanical processes and chemical treatment processes.

22. The acoustic facing of Claim 21, wherein mechanical processes include stretching, bulking, and/or calendaring.

23. The acoustic facing of Claim 21, wherein chemical treatment processes includes finishing, coating, and/or adhesive application.

24. The acoustic facing of Claim 14, wherein the nonwoven fabric comprises fibers selected from the group consisting of polypropylene, polyethylene, polyethylene terephthalate, polyester, acetate, nylon, polylactic acid (PLA), glass, viscose, tencel, rayon, and acrylic fibers, and blends thereof.

25. A laminate comprising the acoustic facing of Claim 13 and at least one additional layer laminated thereto.

26. The laminate of Claim 25, wherein the at least one additional layer is selected from the group consisting of: fiberglass batting, a resinated fiberglass panel, rock wool, plastic foam, urethane foam, shoddy pad from waste fiber, polyester batting or resinated fiberfill, aerogel, closed cell foam, or reticulated foam.

27. The acoustic facing of Claim 25, wherein the at least one additional layer is a decorative fabric layer.

28. A sound absorption laminate, comprising:

first and second acoustic facings, each facing comprising a moldable fabric having a basis weight of from about 1.5 to 5.0 ounces per square yard (osy), a thickness of less than about 0.050" as measured via ASTM D1777, a mean pore size of between about 8 microns and about 40 microns, and an elongation at break of at least twenty percent (20%) as measured via ASTM D5034, wherein the fabric comprises less than about five percent (5%) synthetic microfiber, and wherein the fabric has an acoustic resistance of at least about 250 Rayls; and

a low density layer of material sandwiched between the first and second acoustic facings, wherein the low density layer of material is selected from the group consisting of: fiberglass batting, a resinated fiberglass panel, rock wool, plastic foam, urethane foam, shoddy pad from waste fiber, polyester batting or resinated fiberfill, aerogel, closed cell foam, or reticulated foam.

29. A sound absorption article, comprising:

- a) a facing comprising a moldable fabric having a basis weight of from about 1.5 to 5.0 ounces per square yard (osy), a thickness of less than about 0.050" as measured via ASTM D1777, a mean pore size of between about 8 microns and about 40 microns, and an elongation at break of at least twenty percent (20%) as measured via ASTM D5034, wherein the fabric comprises less than about five percent (5%) synthetic microfiber, and wherein the fabric has an acoustic resistance of at least about 250 Rayls;
- b) a finishing coating for providing one or more additional functional properties to the facing; and
- c) a low density layer of material laminated to the facing.

30. The sound absorption article of Claim 29, wherein the one or more additional functional properties is selected from the group consisting of flame retardancy, adhesive properties, crock resistance, grab tensile, tear strength, color, microbial resistance, electrical conductivity, thermal conductivity, opacity, controllable modulus, water repellency, corrosion resistance, and controllable surface texture.

31. A method of making an acoustically tuned facing, comprising:
preparing a moldable acoustic fabric having a basis weight of from about 1.5 to 5.0 ounces per square yard (osy), a thickness of less than about 0.050" as measured via ASTM D1777, a mean pore size of between about 8 microns and about 40 microns, and an elongation at break of at least twenty percent (20%) as measured via ASTM D5034, wherein the acoustic fabric comprises less than about five percent (5%) synthetic microfiber; and
tuning the fabric to have an acoustic resistance of at least about 250 Rayls, comprising applying a chemical finish to the fabric.

32. The method of Claim 31, wherein tuning the fabric to have an acoustic resistance of at least about 250 Rayls, further comprises subjecting the fabric to one or more mechanical processes selected from the group consisting of stretching, bulking, or calendaring, or a combination thereof.

33. The method of Claim 32, further comprising laminating at least one additional layer to the fabric.

34. The method of Claim 33, wherein the at least one additional layer is: fiberglass batting, a resinated fiberglass panel, rock wool, plastic foam, urethane foam, shoddy pad from waste fiber, polyester batting or resinated fiberfill, aerogel, closed cell foam, or reticulated foam.

35. The method of Claim 33, wherein the at least one additional layer is a decorative fabric layer.

36. A method of making an acoustically tuned facing, comprising:
preparing a moldable fabric having a basis weight of from about 1.5 to 5.0 ounces per square yard (osy), a thickness of less than about 0.050" as measured via ASTM D1777, a mean pore size of between about 8 microns and about 40 microns, and an elongation at break of at least twenty percent (20%) as measured via ASTM D5034, wherein the fabric comprises less than about five percent (5%) synthetic microfiber; and
tuning the fabric to have an acoustic resistance of at least about 250 Rayls, comprising subjecting the fabric to one or more mechanical processes selected from the group consisting of stretching, bulking, or calendaring, or a combination thereof.

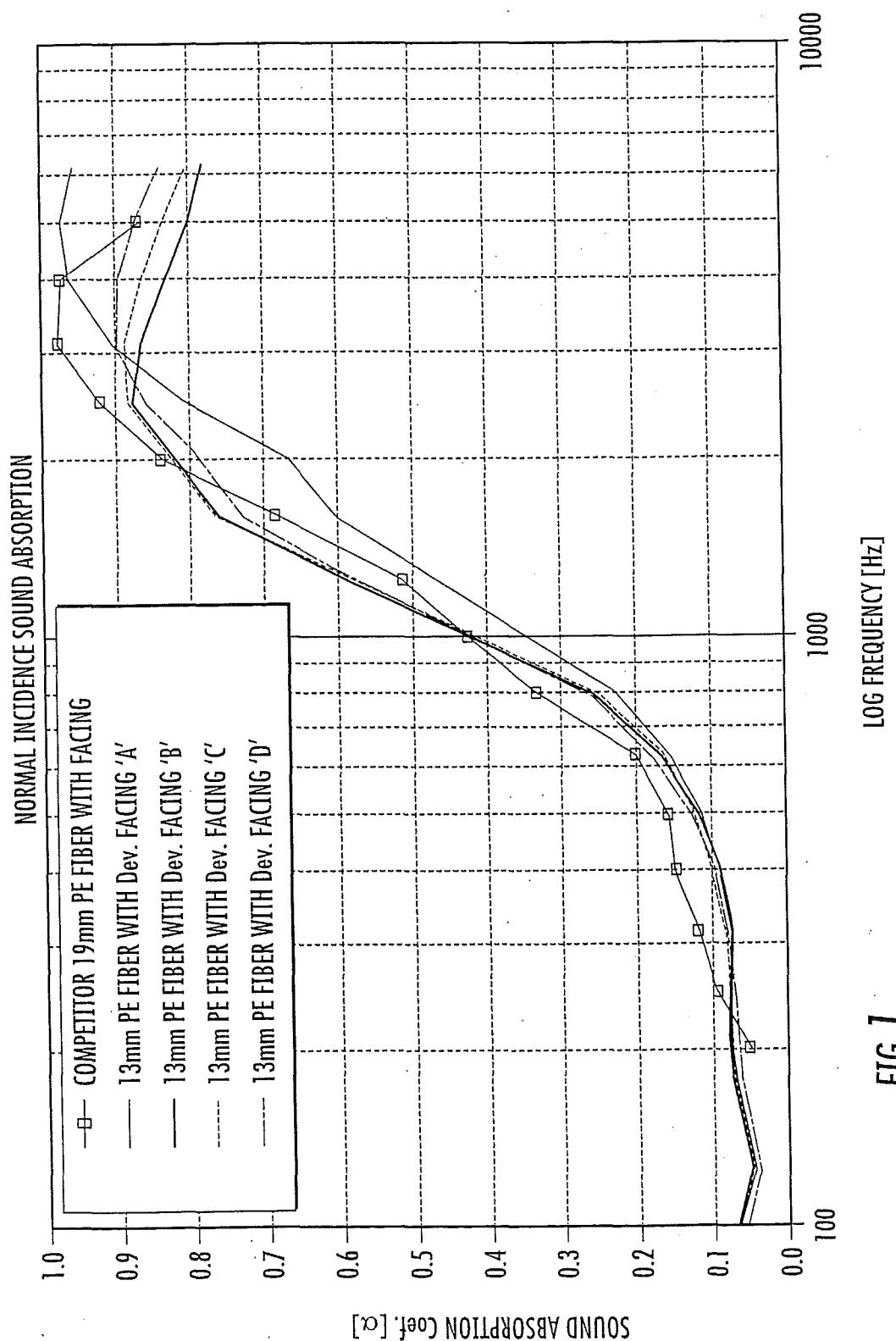
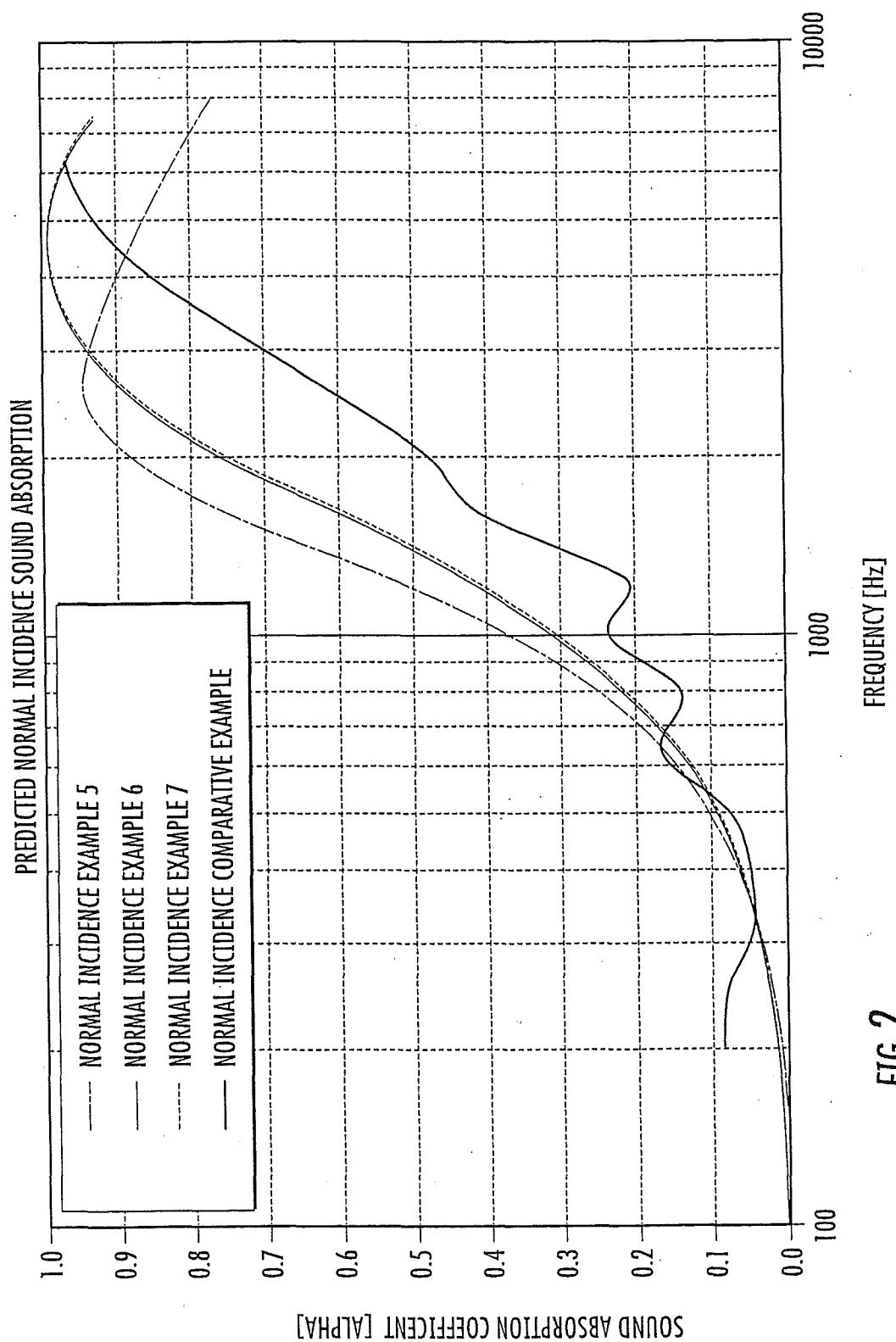


FIG. 1



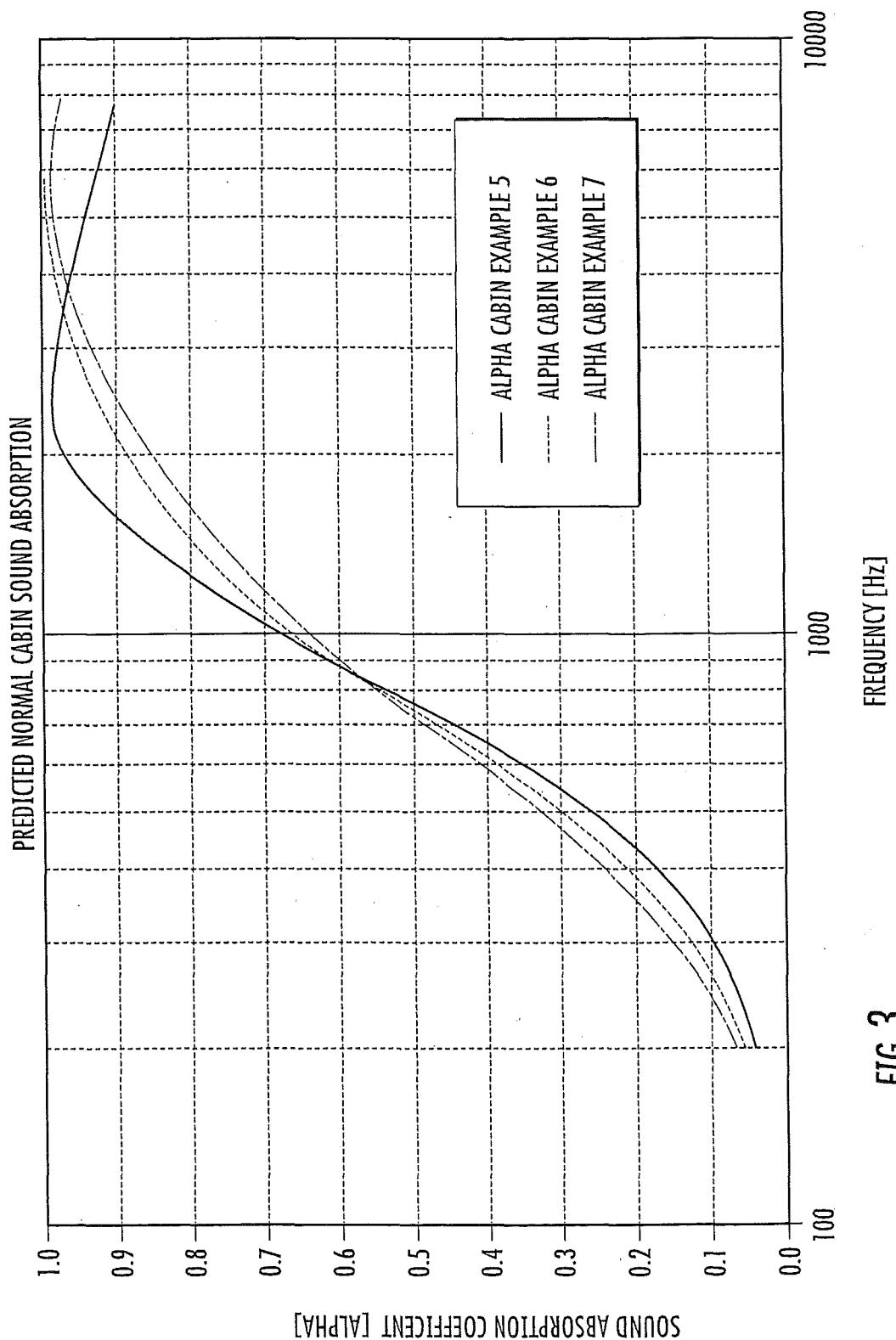


FIG. 3

**Characterization of Acoustic
Materials**

Material	Microfiber	Basis Wt. (osy)	thickness (0.000") ASTM D1777	Density	Air Perm (cfm) Frazier air perm. @ 0.5"WC	Air Perm (Rayls)	Mean Flow Pore Dia. (Microns)
Resin bond 50 gsm	no	1.73	0.016	9.01	518	40	57.84
Resin bond 80 gsm	no	2.68	0.026	8.59	423	49	55.74
8851	no	2.09	0.012	14.49	52	428	18.09
S/8705	no	2.13	0.013	13.63	66	332	23.81
6300-50003	no	2.53	0.020	10.71	210	101	37.19
6300-51003	no	2.60	0.011	20.29	79	277	24.98
6186-50030	no	2.25	0.015	12.21	62	357	19.70
6186-51030	no	2.31	0.010	18.60	28	818	12.94
6079-50001	no	2.74	0.014	16.33	22	1037	12.74
Industry - Incumbent	no	3.10	0.021	12.31	311	68	51.19
Resin bond 267	no	1.34	0.011	10.18	575	36	60.65
Resin bond 4016	no	0.94	0.009	8.73	642	32	57.97
Resin bond 557	no	1.18	0.010	9.81	536	39	54.88
Resin bond 477	no	1.47	0.012	10.19	403	52	51.10
Resin bond 497	no	1.94	0.014	11.55	288	73	43.97
splittable - 060	yes	1.78	0.0097	15.29	121	179	33.00
splittable - 100	yes	2.92	0.0143	17.03	22	1014	11.06
splittable - 130	yes	3.98	0.016	20.71	21	1088	6.39
splittable - 170	yes	5.18	0.028	15.42	8	2858	7.09
80080	yes	1.52	0.0137	9.25	21	1107	6.64
6244-54000	yes	2.01	0.016	10.26	17	1370	6.03

FIG. 4

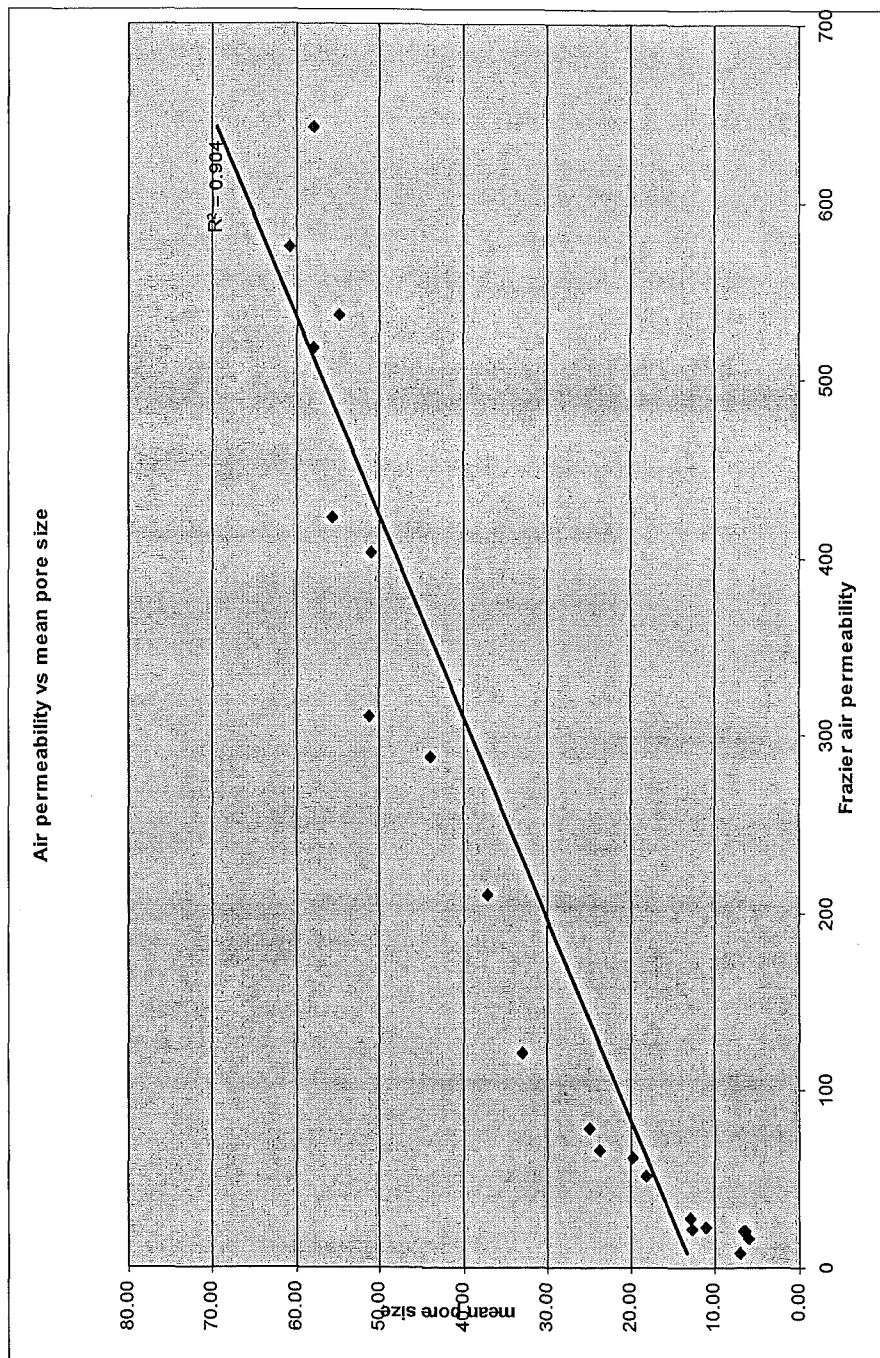


FIG. 5

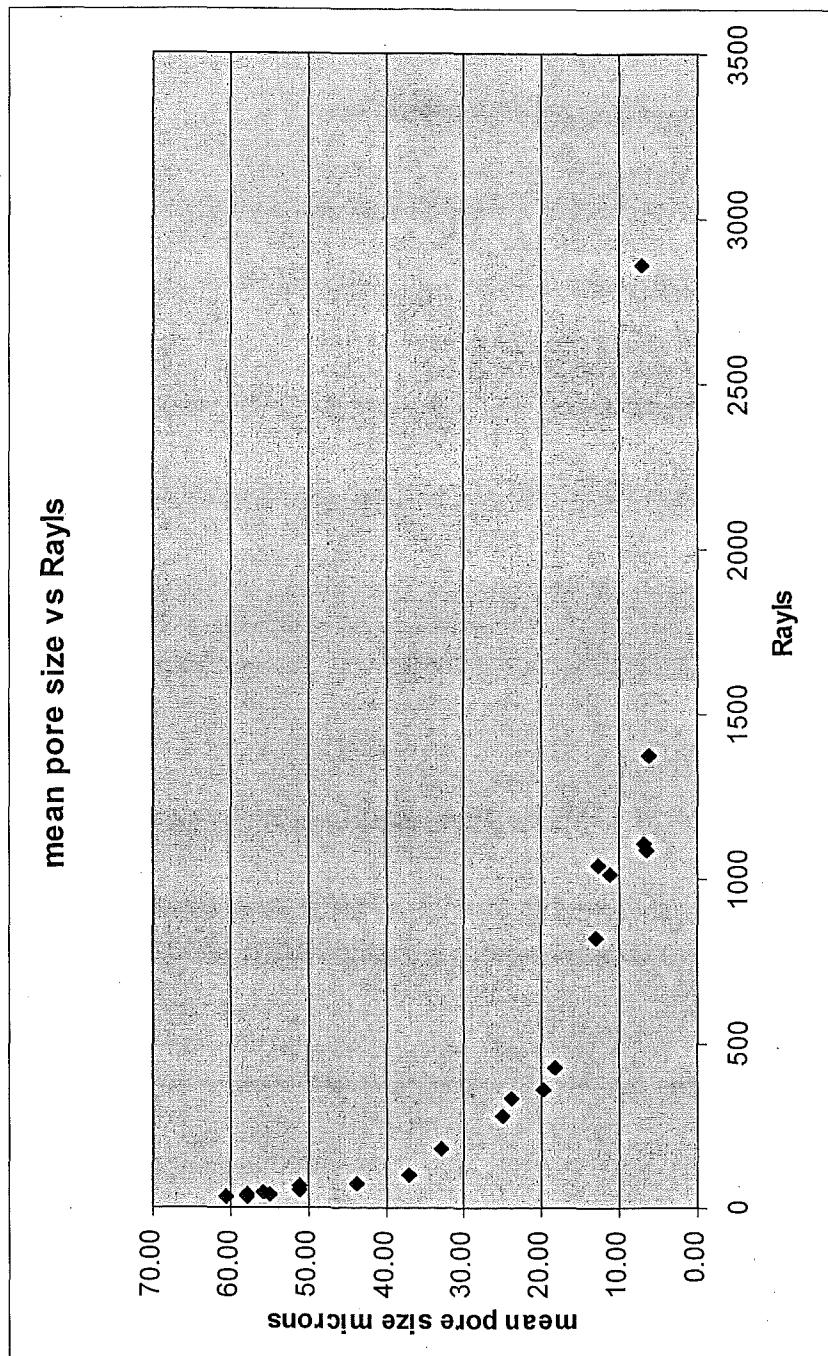


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2010/059844

A. CLASSIFICATION OF SUBJECT MATTER
INV. G10K11/162 G10K11/168
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G10K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2010/038486 A1 (NAGOYA OILCHEMICAL [JP]; OGAWA MASANORI [JP]; FUJII MAKOTO [JP]; MIZUT) 8 April 2010 (2010-04-08) the whole document ----- US 2006/065482 A1 (SCHMIDFT RICHARD J [US] ET AL SCHMIDT RICHARD J [US] ET AL) 30 March 2006 (2006-03-30) paragraph [0002] - paragraph [0003] paragraph [0017] - paragraph [0018] paragraph [0047] - paragraph [0050] figure 5 ----- US 2004/077247 A1 (SCHMIDT RICHARD J [US] ET AL) 22 April 2004 (2004-04-22) paragraph [0009] - paragraph [0012] paragraph [0032] - paragraph [0044] figure 1 ----- -/-	1-36 1,13,31, 36 13,31,36
X		
X		
X		

Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
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Date of the actual completion of the international search	Date of mailing of the international search report
18 March 2011	28/03/2011
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Marquart, N

INTERNATIONAL SEARCH REPORTInternational application No
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