(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
24 December 2014 (24.12.2014)

WIPO | PCT

(10) International Publication Number
WO 2014/201558 A1

(51) International Patent Classification:
G10K 11/168 (2006.01) *B32B 5/02* (2006.01)
B32B 37/12 (2006.01) *B32B 5/26* (2006.01)

(21) International Application Number: PCT/CA2014/050566

(22) International Filing Date: 17 June 2014 (17.06.2014)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/835,803 17 June 2013 (17.06.2013) US

(71) Applicants: **GESTION SOPREMA CANADA INC.** [CA/CA]; 1688 Jean-Berchmans-Michaud, Drummondville, Québec J2C 8E9 (CA). **PROTEC-STYLE INC.** [CA/CA]; 3-1300 boul. Industriel, Granby, Québec J2J 0E5 (CA).

(72) Inventors: **SIMARD, David**; 55 des Cygnes, Granby, Québec J2H 1X5 (CA). **GIRIN, Dorine**; 2868 rue Monsabre, Montréal, Québec H1N 2L2 (CA).

(74) Agent: **ROBIC LLP**; Centre CDP Capital, Bloc E - 8th Floor, 1001 Square-Victoria, Montréal, Québec H2Z 2B7 (CA).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *of inventorship (Rule 4.17(iv))*

Published:

— *with international search report (Art. 21(3))*

(54) Title: SOUND-INSULATING MATERIAL AND METHOD OF MANUFACTURING SAME

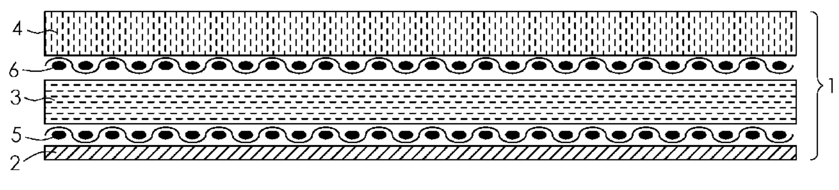

Figure 1

(57) Abstract: A sound insulating material for applying to a surface is provided. The material includes a substrate layer; a first fibrous layer and a second fibrous layer. The first fibrous layer is fixed to the substrate layer and comprises hollow fibers. The second fibrous layer is fixed to the first fibrous layer and also comprises the hollow fibers. The density and the basis weight of the second fibrous layer are each of a different value than the density and the basis weight of the first fibrous layer, respectively.

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SOUND-INSULATING MATERIAL AND METHOD OF MANUFACTURING SAME

FIELD OF THE INVENTION

The present invention relates to an acoustic, or sound-insulating, material for use in buildings and other installations. More particularly, the present invention relates to an acoustic material made at least in part from natural fibers for sound insulation.

BACKGROUND

It is often desirous in the building industry to have effective sound insulation. The density of living spaces is constantly increasing, with many living units fitting into a single building, the condominium being one example of such a building. The people inhabiting these spaces have high expectations for sound insulation, and they do not wish for their comfort and peace of mind to be perturbed by noises emanating either from outside the building, or from an adjacent living unit.

Some decorative elements which are known to enhance sound insulation, such as carpets, rugs, and other floor and wall coverings, are less popular than they traditionally were, which results in greater noise penetration within the living space.

To accommodate this need for greater sound insulation, building codes can require that neighbouring living units be separated by a dividing wall or partition which provides a minimal level of acoustic insulation. It is known to integrate an acoustic material into wall assemblies, as well as into ceilings and floors, so as to provide sound insulation between the two areas divided by these partitions. Such an acoustic material can take many forms, such as semi-rigid or flexible panels, felts, and non-woven wraps provided as rolls or bundles, to name but a few. These materials can be installed between the structural mounts of the walls, or onto the mounts themselves, before being covered up by the wall facings. This technique for installing the acoustic material can assure a continuous covering of the entire surface of the wall without the risk of material pile-up or other associated problems.

These acoustic materials are sometimes made of fibers, either natural or synthetic, and can be manufactured by known techniques (weaving, humid compression, thermobonding, etc.). Some examples of natural fibers include wood fibers and cotton, and examples of synthetic fibers include glass wool, polyester, polypropylene, and rock wool. Each of these fibers is typically cylindrical in shape, being a “full” fiber, and has its own acoustic qualities. When compared to synthetic fibers, natural fibers have certain advantages like the relatively low amount of energy required to transform them into the acoustic material, as well as a relatively low environmental impact while still offering acoustic properties equivalent or superior to those of synthetic fibers.

The Applicant is aware of the following patent documents:

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Although acoustic materials have improved in the recent years, there is still a desire or a need for acoustic materials able to achieve superior acoustic properties over known natural and synthetic acoustic materials or at least similar acoustic properties but at a lower cost.

SUMMARY OF THE INVENTION

An object of the present invention is to provide an acoustic material that fulfills the above mentioned need. Broadly described that object is achieved with a sound-insulating material made at least in part of “hollow” or “tubular” fibers which can be applied to walls, ceilings, floors, and other surfaces so as to improve the sound absorption and/or insulation characteristics of these surfaces.

According to a first general aspect of the invention, there is provided a sound insulating material for applying to a surface, comprising: a substrate layer; a first fibrous layer fixed to the substrate layer, the first fibrous layer comprising hollow fibers, the first fibrous layer having a first density and a first basis weight; and a second fibrous layer fixed to the first fibrous layer, the second fibrous layer comprising the hollow fibers, the second fibrous layer having a second density and a second basis weight, the second density and the second basis weight each being of a different value than the first density and the first basis weight, respectively.

In some implementations, the first density and first basis weight are of a greater value than the second density and the second basis weight, respectively.

In some implementations, the hollow fibers are of a cylindrical form.

In some implementations, the hollow fibers have a length of between 20 mm and 40 mm.

In some implementations, the hollow fibers have a length of between 20 mm and 30 mm.

In some implementations, the hollow fibers have a diameter between 15 microns and 30 microns.

In some implementations, the hollow fibers have an external wall thickness between 1 micron and 2 microns.

In some implementations, the hollow fibers have an external wall thickness of about 1.3 microns.

In some implementations, the substrate layer has a thickness of between 2 microns and 200 microns.

In some implementations, the first fibrous layer has a thickness between 2 mm and 100 mm.

In some implementations, the second fibrous layer has a thickness between 2 mm and 100 mm.

In some implementations, the first basis weight is between about 50 g/m^2 and about 700 g/m^2.

In some implementations, the first basis weight is between about 50 g/m^2 and about 500 g/m^2.

In some implementations, the second basis weight is between about 50 g/m^2 and about 700 g/m^2.

In some implementations, the second basis weight is between about 50 g/m^2 and about 500 g/m^2.

In some implementations, the first density is between 0.015 g/cm^3 and 0.35 g/cm^3.

In some implementations, the first density is between 0.015 g/cm^3 and 0.175 g/cm^3.

In some implementations, the second density is between 0.0026 g/cm^3 and 0.0375 g/cm^3.

In some implementations, the hollow fibers comprise natural hollow fibers.

In some implementations, the natural hollow fibers comprise milkweed fibers.

In some implementations, the first fibrous layer and/or the second fibrous layer further comprise at least one of hemp fibers and flax fibers.

In some implementations, the first fibrous layer and/or the second fibrous layer further comprise additional synthetic fibers.

In some implementations, the additional synthetic fibers comprise thermobonding fibers.

In some implementations, the thermobonding fibers comprise polyethylene and/or polypropylene.

In some implementations, the first fibrous layer comprises between about 70 wt% and about 80 wt% of the hollow fibers and between about 20 wt% and about 30 wt% of the additional synthetic fibers.

In some implementations, the second fibrous layer comprises between about 60 wt% and about 70 wt% of the hollow fibers and between about 30 wt% and 40 wt% of the additional synthetic fibers.

According to another general aspect of the invention, there is provided a method for manufacturing a sound-insulating material, the method comprising: affixing a first fibrous layer comprising hollow fibers onto a substrate layer, thereby forming a first assembly; compressing the first assembly at a first compression temperature, thereby forming a compressed first assembly; affixing a second fibrous layer comprising the hollow fibers onto the compressed first assembly, thereby forming a second assembly; and compressing the second assembly at a second compression temperature, thereby making the sound-insulating material.

In some implementations, the affixing of the first fibrous layer onto the substrate layer comprises: coating the substrate layer with a first adhesive, thereby forming a coated substrate layer; and placing the first fibrous layer onto the coated substrate layer, thereby forming the first assembly.

In some implementations, the affixing of the second fibrous layer onto the compressed first assembly comprises: coating the compressed first assembly with a second adhesive, thereby forming a coated compressed first assembly; and placing the second fibrous layer onto the coated compressed first assembly, thereby forming the second assembly.

In some implementations, the first compression temperature is between about 200 and about 250℃.

In some implementations, the second compression temperature is between about 200 and about 250℃.

In some implementations, there is provided a method for installing a sound-insulating material on a surface to improve sound insulation.

In light of the above, it can be appreciated that the improved sound-insulating material helps to reduce noise entering a space, such as living quarters for example. Such a relatively thin and reliable sound-insulating material allows for dividing walls to be kept to smaller widths, thereby maximising the available living space. Furthermore, the optional use of natural fibers helps reduce the environmental impact of the material, and may further allow it to be approved for use in environmentally-responsible buildings.

Furthermore, such a sound-insulating material may, in some instances, outperform minimal requirements by about 20%, and in some possible situations, by about 35%.

Moreover, the above-described method for manufacturing the material can help reduce the cost and complexity of fabrication, while maintaining appropriate quality control requirements.

The objects, advantages and other features of the present invention will become more apparent upon reading of the following non-restrictive description of optional embodiments thereof, given for the purpose of exemplification only, with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a cut-away view of an embodiment of the sound-insulating material according to the present invention.

Figure 2 is a graph showing the acoustical performance of various materials, including materials comprising milkweed fibers.

Figure 3 is a graph showing the acoustical coefficient of absorption at different frequencies for various materials, including materials comprising milkweed fibers.

Figure 4 is a graph showing the acoustical coefficient of absorption at different frequencies for various materials, including materials A to E comprising milkweed fibers and thermobonding fibers.

Figure 5 is a graph showing the acoustical performance of various materials, including materials A to E comprising milkweed fibers and thermobonding fibers.

Figure 6 is a x750 Scanning Electron Micrograph (SEM) showing milkweed fibers.

Figure 7 is a photograph of an embodiment of the sound-insulating material according to the present invention.

Figure 8 is a photograph of another embodiment of the sound-insulating material according to the present invention.

Figure 9 is a graph showing the acoustical coefficient of absorption at different frequencies for material F.

Figure 10 is a graph showing the acoustical performance of material F

DETAILED DESCRIPTION

In the following description, the same numerical references refer to similar elements. Furthermore, for the sake of simplicity and clarity, namely so as to not unduly burden the figures with several references numbers, not all figures contain references to all the components and features of the present invention and references to some components and features may be found in only one figure, and components and features of the present invention illustrated in other figures can be easily inferred therefrom. The embodiments, geometrical configurations, materials mentioned and/or dimensions shown in the figures are preferred, for exemplification purposes only.

Moreover, although the sound-insulating material disclosed herein was primarily designed to reduce noise penetration for surfaces in the construction industry, it may be used with other types of devices and/or products, and in other field as for example it can also be used in the field of road transport to insulate the walls of a trailer, a motorhome, a van, an ambulance etc.

In addition, although the optional embodiments shown in the accompanying drawings comprise various components and consist of certain geometrical configurations as explained and illustrated herein, not all of these components and geometries are essential and thus should not be taken in their restrictive sense, i.e. should not be taken as to limit the scope of the present disclosure.

A Sound-Insulating Material

Broadly described, the sound-insulating material disclosed herein is a product which can offer excellent sound insulation while being relatively easy to manufacture. In some embodiments, the product is even more easy to manufacture as it is made from sustainable natural resources. The sound-insulating material is made at least in part from hollow fibers, and optionally from natural fibers, which can improve the acoustic efficiency of the material.

Referring to Figure 1, the sound-insulating material 1 (or simply “material 1”) is intended to be applied to surfaces so as to improve the sound insulation characteristics of these surfaces. The expressions “sound-insulating” or “sound insulation” as used herein refer to the ability of the material 1 to prevent, reduce, absorb, dampen, etc. the transmission of sound emanating from one side of the material 1 to its other side. The term “surface” as used herein refers to any wall, ceiling, floor, barrier, or other similar structure which serves to define a space, and for which it is desired to impart sound insulation. As such, the “surface” mentioned herein is not limited to a particular shape or configuration.

The material 1 itself can take many forms depending on the application for which it is intended. In one possible example, the layers of the material 1 can be assembled to form a felt, which can be draped or applied to the surfaces, thereby improving their sound insulation properties. In such an application, the material 1 can be used in a partition wall in a living space, or in a floor or ceiling assembly separating two living spaces, to name but a couple of examples, thereby helping to provide these spaces with excellent acoustical absorption and insulation properties. In another possible example, the material 1 can be installed in a continuous fashion on the interior of exterior walls, thereby providing the space enclosed by these walls with improved sound insulation characteristics. In yet another possible example, the material 1 can be a flexible board or panel made to any suitable shape and size, which can be used alone or applied to the surfaces. It is thus apparent that the material 1 is not limited to a particular form, application, or installation, and can be manufactured or adapted for the purpose which it will serve.

The material 1 has a substrate layer 2. The substrate layer 2 acts as a support for the other layers, and provides a measure of structure to the material 1. The substrate layer 2 can also be used to impart other desirable characteristics to the material 1, such as resistivity to, or conductance of heat or electricity, for example. As such, the substrate layer 2 can take any suitable form or shape, and be made of any suitable material. In some possible embodiments, the substrate layer 2 consists of a metallized polymer film, where the polymer film can be made from polyethylene, polypropylene, and/or polyester, to name but a few materials. In other possible embodiments, the substrate layer 2 can be made of successive layers of polymer film which are combined with a relatively thin metallic sheet, such as one made out of aluminum. Such a substrate layer 2 may increase the sound insulation properties of the material 1 even further. The thickness of the substrate layer 2 can vary depending on the application for which the material 1 is used. Indeed, it may be possible to increase the sound insulation properties of the material 1 by increasing the thickness of the substrate layer 2. Some examples of thickness values for the substrate layer 2 range from about 2 to about 200 microns, but the thickness is not limited to this range.

The material 1 also has a first fibrous layer 3 (or simply “first layer 3”) which is fixed to the substrate layer 2. The terms “fiber” or “fibrous” refer to a natural or synthetic filament or thread which can be manipulated to form the layers of the material 1. The term “layer” as used herein to describe fibrous layers refers to an assembly of the fibers into a given thickness or mat which can impart the desired sound insulating properties.

The first layer 3 is formed at least in part by a plurality of hollow fibers. The expression “at least in part” refers to the presence of the hollow fibers within the first layer 3. For example, the hollow fibers can form a certain percentage of all the fibers within the first layer 3, or can make up the entire first layer 3. In the optional embodiment where the hollow fibers make up a certain percentage of all the fibers, the remaining percentage can consist of non-hollow fibers, either synthetic or natural, for example. The actual percentage of hollow fibers making up the first layer 3 can vary depending upon numerous factors, such as the cost of the fibers, the intended application of the material 1, the manner by which the material 1 will be installed, etc. For example, in an embodiment, the first layer 3 can include between about 70 wt% and about 80 wt% of hollow fibers, and between about 20 wt% to about 30 wt% of non-hollow fibers. The non-hollow fibers may include natural and/or synthetic non-hollow fibers. For example, in another embodiment, in the first layer 3, the hollow fibers can make up about 80 wt% of the total mass of fibers.The first layer 3 contains hollow fibers. The term “hollow fiber” refers to a fiber, either synthetic or natural, which has a largely empty or void interior and which has a low density when compared to non-hollow or “full” fibers. Such hollow fibers can advantageously improve sound absorption as a result of their empty interiors, and also as a result of their relatively low densities. Although hollow fibers can be produced from synthetic source material, it can often be more cost-effective and environmentally friendly to produce these hollow fibers from natural materials. Hollow fibers made from natural materials may demonstrate certain advantages over fibers made from synthetic materials, in that natural fibers may require lower amounts of energy to assemble into the material 1, and they may have fewer environmental impacts while still offering similar or superior acoustic properties. One example of a hollow natural fiber is milkweed fiber, which can provide beneficial acoustic properties. In some possible embodiments, milkweed fiber (or *asclepias syriaca*) can take a cylindrical form, and the individual fibers can measure between about 20 and about 40 mm, with a diameter ranging from about 15 to about 30 microns, and an external wall thickness of between 1 micron and 2 micron. The diameter and wall thickness can be seen, for example on the photograph shown on Figure 6. For example, the external wall thickness can be of about 1.3 microns. The hollow natural fibers can make up about 80 wt% of the total mass of fibers in the first layer 3.

Other natural fibers, which are not necessarily hollow, may also be used in the first layer 3. Some examples of these natural materials include flax fiber, and hemp fiber, but other natural materials and/or combinations of these can also be used.

The manner by which the hollow fibers are manipulated to form the first layer 3 provides the first layer 3 with a certain density, e.g. a first density, and a certain basis weight, e.g. a first basis weight. The hollow fibers can be woven or non-woven, depending on the application for which the material 1 is intended. The densities described herein are a measure of mass of the fibers per volume of the fibrous layer. For example, the first density can have a value ranging from about 0.015 g/cm^3 to about 0.35 g/cm^3, or from about 0.015 g/cm^3 to about 0.175 g/cm^3. Other first density values are possible. The basis weight (also known as “grammage”) denotes the mass of the hollow fiber present in the first layer 3 per unit of area of the first layer 3. In some possible embodiments, the basis weight of the first fibrous layer 3 can vary between about 50 and about 700 g/m^2, or between about 50 and about 500 g/m^2. The thickness of the fibrous layers can also vary. Some possible values for the thickness include about 2 to about 100 mm. It will be appreciated that these values are given for illustrative purposes only, and that they may have the same or different values discussed above, depending on the particular application for which the material 1 may be used, for example.

Still referring to Figure 1, and as discussed above, the material 1 has a second fibrous layer 4 (or simply “second layer 4”) fixed to the first layer 3. The second layer 4 is also made, at least in part, from a plurality of hollow fibers, such as the ones described above. As with the first layer 3, the second layer 4 has a second basis weight and a second density. Optionally, the second density has a value which is lower than the value of the first density, and the second basis weight has a value which is lower than the value of the first basis weight. For example, the second density may have a value in the range of about 0.0026 g/cm^3 to about 0.0375 g/cm^3.

The density and basis weight of the fibrous layers 3, 4 can affect the acoustical performance of the material 1. For example, the density of the fibrous layer is known to effect the sound insulation of the material 1. As density values are increased, the fibrous layer may have a greater tendency to reflect or deflect sound waves, thereby preventing them from penetrating through the first layer 3. It can thus be appreciated that, in the optional embodiment described above, the first layer 3, with its greater first density value, is denser that the second fibrous layer 4. The first layer 3 will thus have a greater tendency (when compared to second layer 4) to reflect or deflect oncoming sound waves. The second layer 4, with its lower second density value, is less dense that the first layer 3, and will thus have a greater tendency to diffuse or dampen the intensity/energy of the oncoming sound waves, thereby improving the sound absorption properties of the material 1. It can thus be appreciated that two measures of acoustical insulation (i.e. sound insulation and sound absorption) are advantageously addressed with first and second layers 3, 4.

In some optional embodiments, the material 1 can include only a single fibrous layer, whose density and basis weight values vary. Further optionally, these values can vary by decreasing in magnitude in a direction away from the substrate layer 2 or surface against which the material 1 is installed.

The basis weight value of the first and second layers 3, 4 can act as a multiplier of the effect provided (i.e. insulation and absorption) by the density values.

The manner by which the first layer 3 is fixed to the substrate layer 2, and by which the first layer 3 is fixed to the second layer 4, can vary. In some possible embodiments, an example of which is shown in Figure 1, adhesives 5, 6 are used to bond one side of a layer to a corresponding side of another layer. Optionally, the adhesives 5, 6 can consist of liquid glue. Further optionally, the adhesives 5, 6 can be adhesive webs, such as a thermoplastic adhesive web. Such adhesive webs can consist of a planar but discontinuous material which, when exposed to heat, becomes active and adheres to the targeted surfaces of the layers, thereby creating a link between the layers and fixing them together. This material can be made from a base of polymer EVA (Ethylene Vinyl Acetate), having a basis weight of about 24 g/m^2. In the particular case where the first layer 3 is bonded to the substrate layer 2, the adhesive web 5 can be based in a co-polyamide having a basis weight of about 20 g/m^2. Other types of adhesives and/or adhesive webs can be used, such as those having a polyester or polyethylene base, for example. In some possible embodiments, an example of which is shown in Figure 1, a thermoplastic adhesive web 5 is used to bond the substrate layer 2 to the first layer 3. Further optionally, an inter-layer thermoplastic adhesive web 6 can be used to bond the first layer 3 to the second layer 4.

Method for Manufacturing a Sound-Insulating Material

Having described examples of possible sound-insulating materials, an example of a method for manufacturing such a material will now be discussed, in relation to the optional use of hollow milkweed fiber for the first and second layers.

The hollow milkweed fibers can be prepared directly from clean harvested milkweed after it has been processed to remove grains and other debris resulting from harvesting. The milkweed fibers can be mixed with synthetic fibers, such as a bi-component. The synthetic fibers used for thermal-bonding (i.e. thermobonding fibers) can for example include a polypropylene center wrapped or surrounded in a sheath of polyethylene. The synthetic fibers can help to bond the natural fibers together because the synthetic fibers can be melted under pressure and/or heat so as to integrate the natural fibers with each other. In some optional embodiments, the percentage of hollow fibers such as milkweed fibers within the first layer 3 can vary between about 50 wt% and about 90 wt%, or between about 70 wt% and about 80 wt%. In some optional embodiments, the first layer can have a mixture of about 80 wt% natural fiber, and about 20%, by weight, synthetic fiber. In some optional embodiments, the less dense second layer, can include between about 60 wt% and about 70 wt% of hollow fibers such as milkweed fibers. In some optional embodiments, the second layer may have a mixture consisting of about 70 wt% of natural fiber, and about 30 wt% of synthetic fiber. More than two types of fibers can be mixed depending on numerous factors such as the cost of fiber material, its availability, and the intended application of the material. These mixed fibers can be carded so as to disentangle, clean, and intermix them together, thus producing unconsolidated first and second veils which will become the first and second layers discussed above.

The method includes a first affixing step of affixing the first layer including the hollow fibers onto the substrate layer, thereby forming a first assembly. The first affixing step can include coating the substrate layer with an adhesive, such as the adhesive web described above, for forming a coated substrate layer. The first affixing step can also include placing the first layer (i.e. first veil) of hollow fibers onto the coated substrate layer, thereby forming a first assembly of hollow fibers. Optionally, the veil which forms the first layer may have a first basis weight in the range of about 50 to about 700 g/m^2, or in the range of about 50 to about 500 g/m^2.

The method also includes the step of compressing the first assembly at a first compression temperature, thereby forming a compressed first assembly. In some optional embodiments, the first assembly is placed into a press and heated to a temperature in the range of about 200 to about 250°C. The fibers and the substrate layer are pressed together under relatively high pressure for a bonding duration which allows the first layer to bond to the substrate layer, thereby forming the first assembly which will remain integral.

The method also includes a second affixing step of affixing the second layer including the hollow fibers onto the compressed first assembly.

In some optional embodiments, the second affixing step includes coating the compressed first assembly with an adhesive, which can be performed in a manner similar to the coating of the first layer, thereby forming a coated compressed first assembly. The second fibrous layer can then be placed onto the coated compressed first assembly, thereby forming a second assembly.

Alternatively, in other optional embodiments, the second affixing step can include coating the second layer with an adhesive, which can be performed in a manner similar to the coating of the first layer, thereby forming a coated second layer. The coated second layer can then be placed onto the compressed first assembly, thereby forming the second assembly.

In some optional embodiments, the second layer (i.e. second veil) can be prepared similarly to the first layer, where a second unconsolidated veil having a basis weight in the range of about 50 to about 700 g/m^2, or of about 50 to about 500 g/m^2, is placed on an inter-layer thermoplastic adhesive web so as to form the second assembly. This bonds the second layer to the first assembly. The second layer can have a density and basis weight which differs from, or is the same as, the density and basis weight of the first layer.

The method also includes compressing the second assembly at a second compression temperature. In some optional embodiments, the second layer and the first assembly are placed into a press and heated to a temperature in the range of about 200 to about 250℃, and further optionally to about 220℃. The second assembly is compressed under relatively high pressure for another bonding duration, which can be similar or different than the previous bonding duration, and which binds the second layer to the first assembly, thereby forming the material.

The steps of the method described above can also be varied or their order changed, as required. For example, the first layer can be coated with an adhesive so as to receive thereon the second layer.

Such a sound-insulating material can be dimensioned and shaped in various ways. In one possible embodiment, the material can be supplied as a roll about 1 m wide, about 8 m long, and having a nominal thickness of about 10 mm. In another embodiment, the material can be supplied as a rigid panel.

EXAMPLES

Example 1: preliminary test

Experiments were performed to compare the acoustical performance of materials made from one layer of hollow milkweed fibers versus full flax, hemp, polyester and glass wool fibers. The results are shown in Figure 2.

The test which generated the results of the graph was carried out in an acoustic impedance tube, and used fibers of various densities, as shown in Figure 2. The test aimed at determining the transmission losses at normal impedance (nSTL) for the different fibers at various frequencies (Hz), each material having the same basis weight of about 450 g/m^2 and thickness of 12.5 mm.

As can be seen, the losses in the material made from milkweed fibers were about 15 dB at all frequency levels, which are greater than the losses produced by the other fibers. When compared to the other types of fibers at a same basis weight, the milkweed fiber represents a significant gain in acoustic performance.

Example 2: preliminary test

Experiments were performed to compare the coefficient of acoustic absorption for different types of fibers across a wide frequency range, and at different thicknesses. The results are shown in Figure 3.

The coefficient of acoustic absorption is a measure of each fiber's ability to dissipate acoustic energy, and values which are closer to 1 indicate greater sound insulation capabilities. The fibers compared were various thicknesses of milkweed (one layer), polyester (Acoustizol^{TM}) and glass wool, where each fiber had roughly the same basis weight. As can be seen, the glass fiber had the highest coefficient value, but as shown in Figure 2, had lower transmission losses. The various thicknesses of milkweed fiber provided suitable coefficient values, while having the highest transmission losses.

Example 3

Experiments were performed to compare the coefficient of acoustic absorption and the acoustical performance of different materials across a wide frequency range. The composition, basis weight and physical properties of the materials tested are shown in Tables 1 to 5 below, and the results are shown in Figures 4, 5, 9 and 10.

Table 1: Composition and basis weight of Materials A to C

Basis weight (g/m^2)	**Material A**	**Material B**	**Material C**
Total basis weight	612.5	920	910
Layer 3	Milkweed: 210 Thermobonding fibers: 52.5	Milkweed: 429 Thermobonding fibers: 184	Milkweed: 380 Thermobonding fibers: 163
Layer 4	Milkweed: 137 Thermobonding fibers: 59	Milkweed: 107 Thermobonding fibers: 46	Milkweed: 149 Thermobonding fibers: 64
Aluminum substrate	110	110	110
Web adhesive between substrate and layer 3	20	20	20

Web adhesive between layers 3 and 4	24	24	24

Table 2: Density and thickness of the layers 3 and 4 of materials A to C

	Material A	Material B	Material C
Layer 3 Thickness (mm)	5	12	3.6
Layer 3 Density (g/cm^3)	0.053	0.051	0.015
Layer 4 Thickness (mm)	26	12	22.6
Layer 4 Density (g/cm^3)	0.008	0.013	0.009

For layers 3 and 4 in materials A to C, the milkweed fibers had a mean length in the range of about 20 mm to about 40 mm, and the thermobonding fibers (polyethylene-polypropylene fibers) had a mean length of about 40 mm.

Table 4: basis weight of the comparative materials tested

	Glass wool with aluminum film	**Polyester with aluminum film (Acoustizol™)**
Basis weight (g/m^2)	1352	450

The glass wool with aluminum film had a thickness of about 1 inch (25.4 mm), and a density of 0.05 g/cm^3.

Table 5: Composition and basis weight of Material D (one layer of fibers)

Basis weight (g/m^2)	**Material D**

Total basis weight	658
Fiber layer	Milkweed: 410.4 Thermobonding fibers: 102.6
Aluminum substrate	110
Web adhesive between substrate and fiber layer	35

In material D, the milkweed fibers had a mean length in the range of about 20 mm to about 40 mm, and the thermobonding fibers (polyethylene-polypropylene fibers) had a mean length of about 40 mm.

Referring to Figures 4 and 9, the tests which generated the results of the graphs were carried out in an acoustic impedance tube. The tests aimed to compare the coefficient of acoustic absorption for different materials across a wide frequency range. It can be seen that materials A to C have better acoustic absorption than polyester-based films. Material A and material B have better acoustic absorption than glass wool. Material D has only one layer including hollow fibers. The acoustic absorption of material D is lower than the acoustic absorption of materials B and C, while being comparable to the acoustic absorption of material A.

Referring to Figures 5 and 10, the tests aimed to compare the acoustic isolation for different materials across a wide frequency range. It can be seen that materials A to C have better acoustic isolation than polyester-based films. Further, material C has better acoustic isolation than glass wool, and material B has an acoustic isolation comparable to glass wool. It can also be seen that material D has a lower acoustic isolation than materials B and C.

Materials A to C are also advantageous because of their lower basis weight compared to glass wool, making them more convenient to install and handle than glass wool.

Figure 7 shows a photograph of an embodiment of the sound-insulating material of the invention (material A), to be applied, for example to walls and other surfaces in buildings.

Figure 8 shows a photograph of another embodiment of the sound-insulating material of the invention (material C), to be used, for example as sound-insulating panels in ambulances.

Table 6: Figure caption

Figure 2	12 14 16 18 20	milkweed polyester + aluminum film (Acoustizol) glass wool flax hemp
Figure 3	22 24 26 14 16	20 mm milkweed 15 mm milkweed 12.5 mm milkweed polyester + aluminum film (Acoustizol) glass wool
Figures 4-5	28 30 32 34 14	material A glass wool + aluminum film material B material C polyester + aluminum film (Acoustizol)
Figures 9-10	36	material D

Of course, numerous modifications could be made to the above-described embodiments without departing from the scope of the disclosure.

CLAIMS

1. A sound insulating material for applying to a surface, comprising:

   a substrate layer;

   a first fibrous layer fixed to the substrate layer, the first fibrous layer comprising hollow fibers, the first fibrous layer having a first density and a first basis weight; and

   a second fibrous layer fixed to the first fibrous layer, the second fibrous layer comprising the hollow fibers, the second fibrous layer having a second density and a second basis weight, the second density and the second basis weight each being of a different value than the first density and the first basis weight, respectively.

2. The sound insulating material of claim 1, wherein the first density and first basis weight are of a greater value than the second density and the second basis weight, respectively.

3. The sound insulating material of claim 1 or 2, wherein the hollow fibers are of a cylindrical form.

4. The sound insulating material of any one of claims 1 to 3, wherein the hollow fibers have a length of between 20 mm and 40 mm.

5. The sound insulating material of claim 4, wherein the hollow fibers have a length of between 20 mm and 30 mm.

6. The sound insulating material of any one of claims 1 to 5, wherein the hollow fibers have a diameter between 15 microns and 30 microns.

7. The sound insulating material of any one of claims 1 to 6, wherein the hollow fibers have an external wall thickness between 1 micron and 2 microns.

8. The sound insulating material of claim 7, wherein the hollow fibers have an external wall thickness of about 1.3 microns.

9. The sound insulating material of any one of claims 1 to 8, wherein the substrate layer has a thickness of between 2 microns and 200 microns.

10. The sound insulating material of any one of claims 1 to 9, wherein the first fibrous layer has a thickness between 2 mm and 100 mm.

11. The sound insulating material of any one of claims 1 to 10, wherein the second fibrous layer has a thickness between 2 mm and 100 mm.

12. The sound insulating material of any one of claims 1 to 11, wherein the first basis weight is between about 50 g/m^2 and about 700 g/m^2.

13. The sound insulating material of claim 12, wherein the first basis weight is between about 50 g/m^2 and about 500 g/m^2.

14. The sound insulating material of any one of claims 1 to 13, wherein the second basis weight is between about 50 g/m^2 and about 700 g/m^2.

15. The sound insulating material of claim 14, wherein the second basis weight is between about 50 g/m^2 and about 500 g/m^2.

16. The sound insulating material of any one of claims 1 to 15, wherein the first density is between 0.015 g/cm^3 and 0.35 g/cm^3.

17. The sound insulating material of claim 16, wherein the first density is between 0.015 g/cm^3 and 0.175 g/cm^3.

18. The sound insulating material of any one of claims 1 to 17, wherein the second density is between 0.0026 g/cm^3 and 0.0375 g/cm^3.

19. The sound insulating material of any one of claims 1 to 18, wherein the hollow fibers comprise natural hollow fibers.

20. The sound insulating material of claim 19, wherein the natural hollow fibers comprise milkweed fibers.

21. The sound insulating material of any one of claims 1 to 20, wherein the first fibrous layer and/or the second fibrous layer further comprise at least one of hemp fibers and flax fibers.

22. The sound insulating material of any one of claims 1 to 21, wherein the first fibrous layer and/or the second fibrous layer further comprise additional synthetic fibers.

23. The sound insulating material of any one of claims 1 to 22, wherein the additional synthetic fibers comprise thermobonding fibers.

24. The sound insulating material of claim 23, wherein the thermobonding fibers comprise polyethylene and/or polypropylene.

25. The sound insulating material of any one of claims 22 to 24, wherein the first fibrous layer comprises between about 70 wt% and about 80 wt% of the hollow fibers and between about 20 wt% and about 30 wt% of the additional synthetic fibers.

26. The sound insulating material of any one of claims 22 to 25, wherein the second fibrous layer comprises between about 60 wt% and about 70 wt% of the hollow fibers and between about 30 wt% and 40 wt% of the additional synthetic fibers.

27. A method for manufacturing a sound-insulating material , the method comprising:

affixing a first fibrous layer comprising hollow fibers onto a substrate layer, thereby forming a first assembly;

compressing the first assembly at a first compression temperature, thereby forming a compressed first assembly;

affixing a second fibrous layer comprising the hollow fibers onto the compressed first assembly, thereby forming a second assembly; and compressing the second assembly at a second compression temperature, thereby making the sound-insulating material.

28. The method of claim 27, wherein the affixing of the first fibrous layer onto the substrate layer comprises:

    a. coating the substrate layer with a first adhesive, thereby forming a coated substrate layer; and

    b. placing the first fibrous layer onto the coated substrate layer, thereby forming the first assembly.

29. The method of claim 28, wherein the affixing of the second fibrous layer onto the compressed first assembly comprises:

    a. coating the compressed first assembly with a second adhesive, thereby forming a coated compressed first assembly; and

    b. .placing the second fibrous layer onto the coated compressed first assembly, thereby forming the second assembly.

30. The method of any one of claims 27 to 29, wherein the first compression temperature is between about 200 and about 250℃.

31. The method of any one of claims 27 or 30, wherein the second compression temperature is between about 200 and about 250℃.

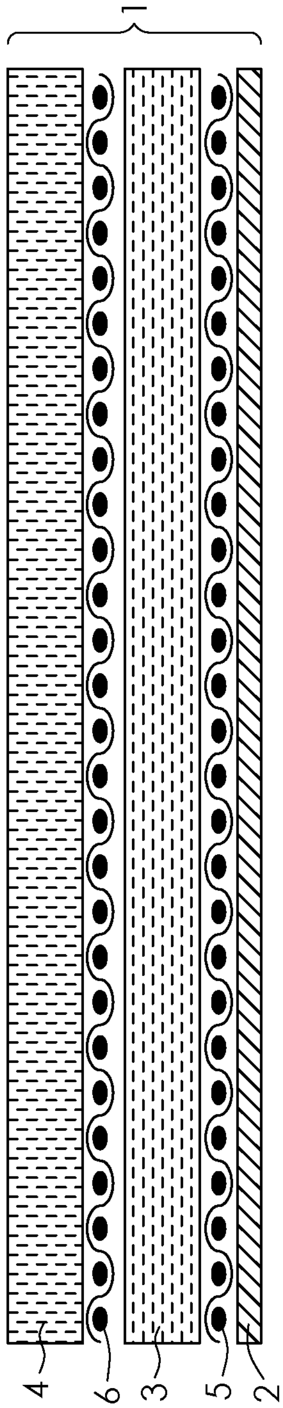
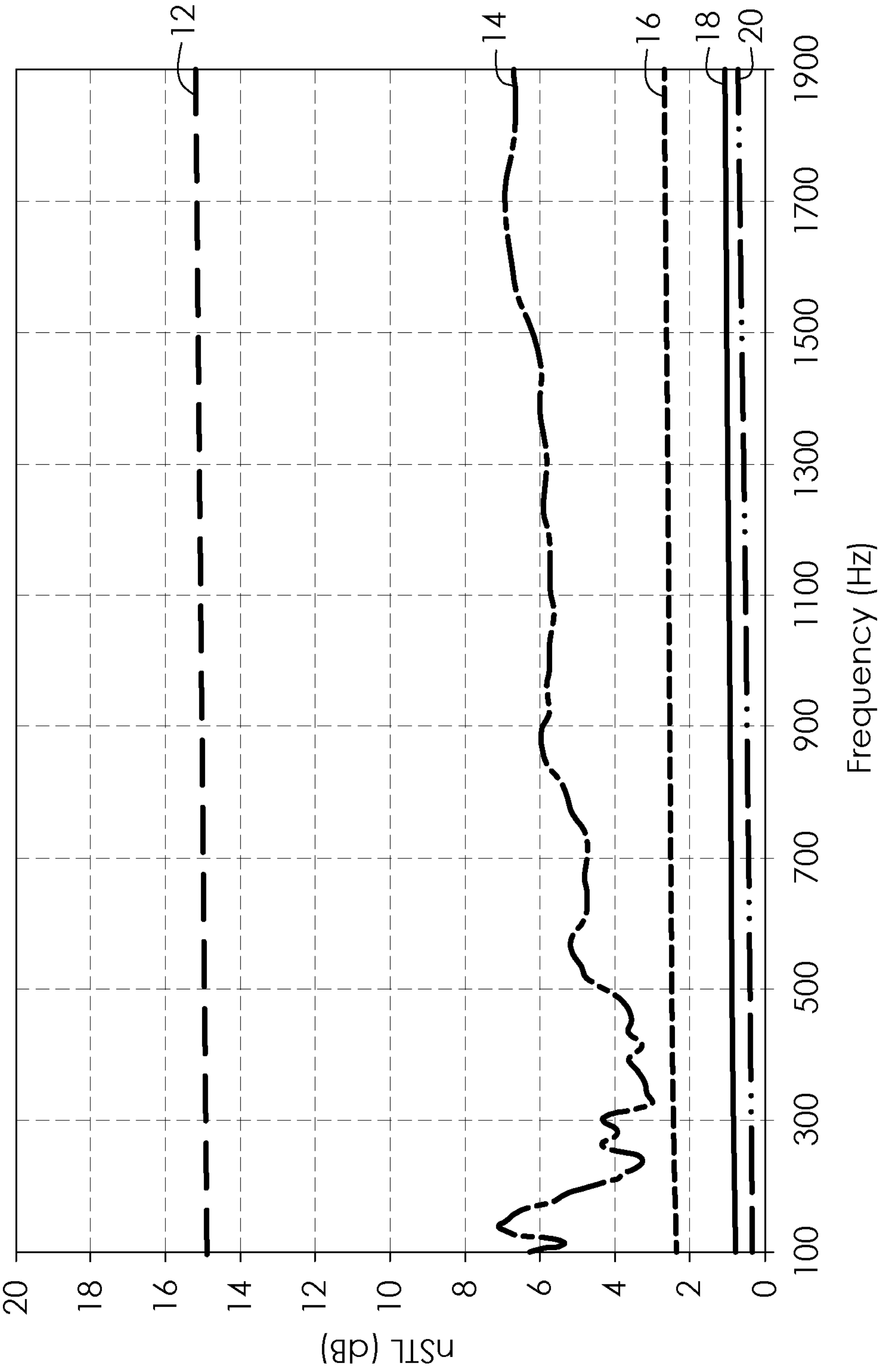


Figure 1



nSTL (dB)
0
2
4
6
8
10
12
14
16
18
20
Frequency (Hz)
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300
500
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900
1100
1300
1500
1700
1900
12
14
16
18
20

Figure 2

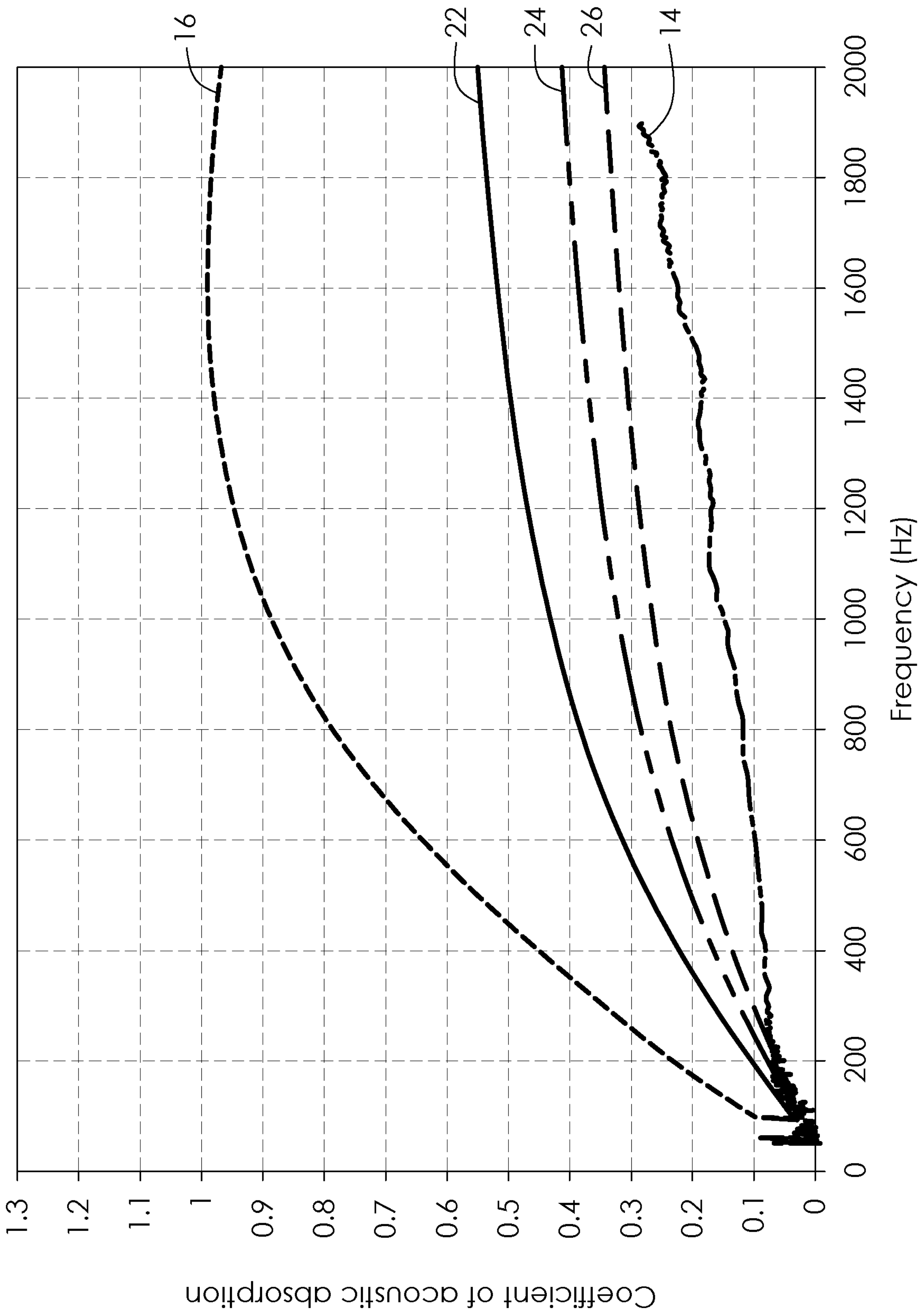

Coefficient of acoustic absorption
Frequency (Hz)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
0
200
400
600
800
1000
1200
1400
1600
1800
2000
16
22
24
26
14

Figure 3

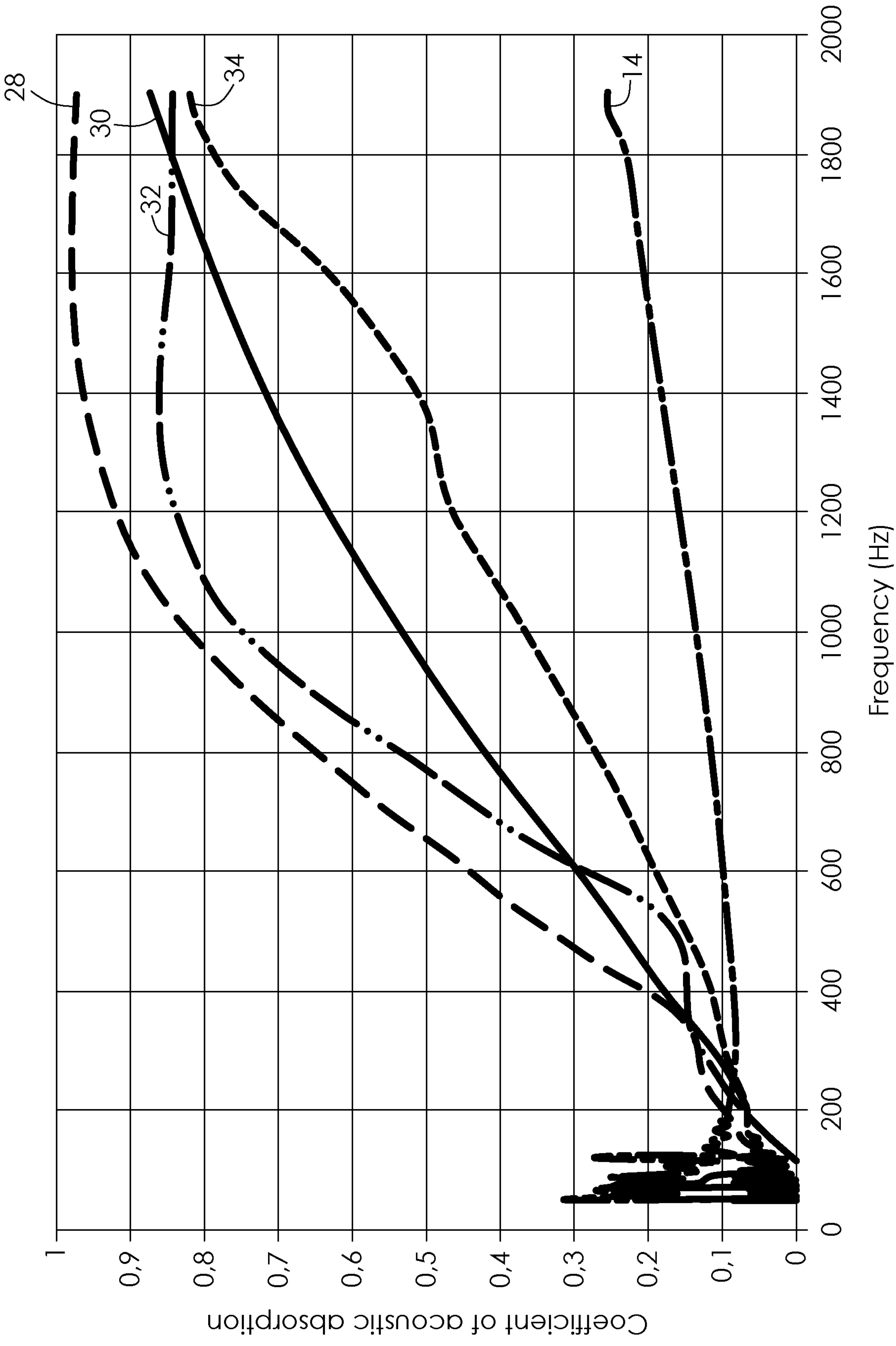

Coefficient of acoustic absorption
0
0,1
0,2
0,3
0,4
0,5
0,6
0,7
0,8
0,9
1
Frequency (Hz)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
28
30
32
34
14

Figure 4

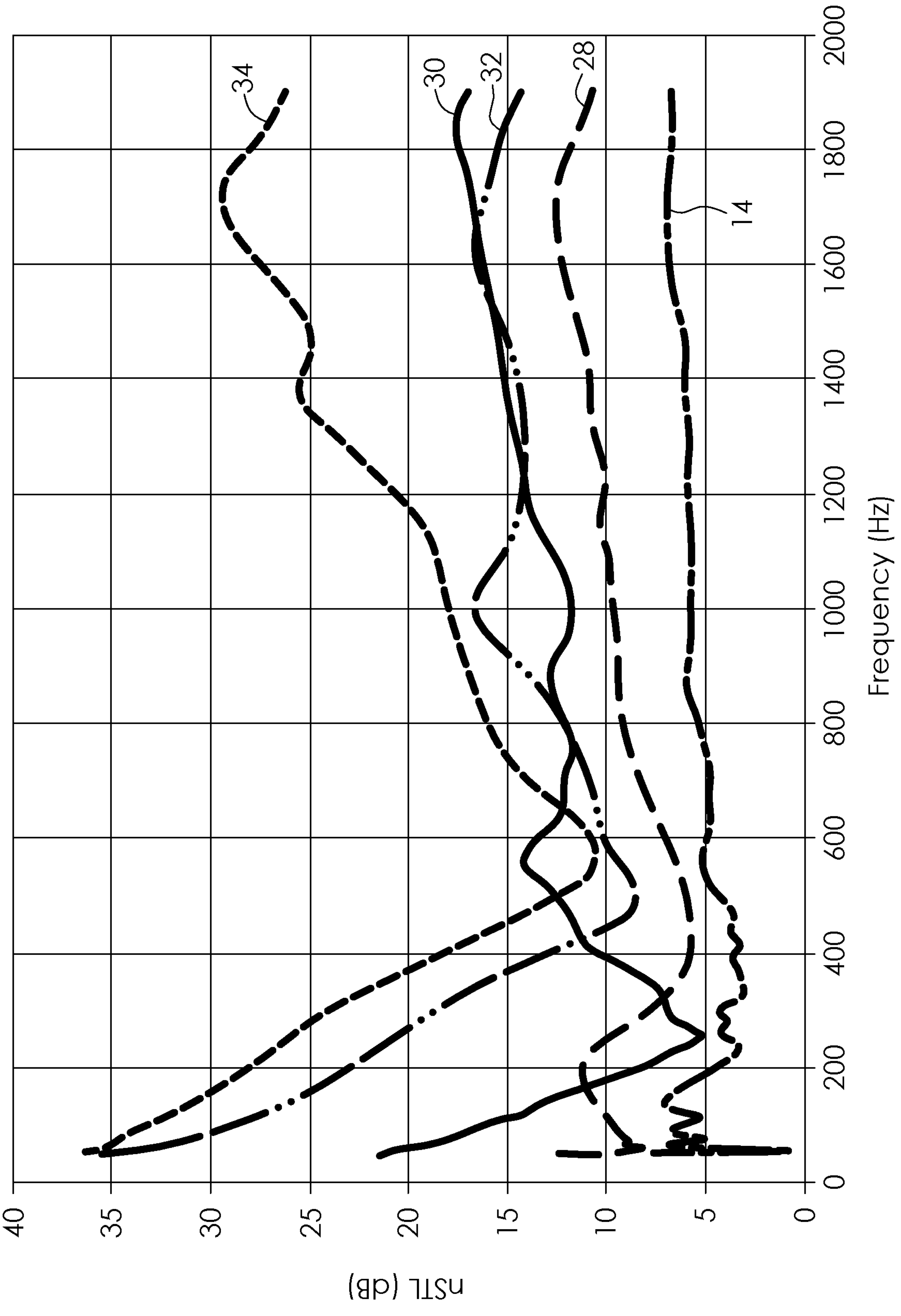

nSTL (dB)
0
5
10
15
20
25
30
35
40
Frequency (Hz)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
34
30
32
28
14

Figure 5

Figure 6

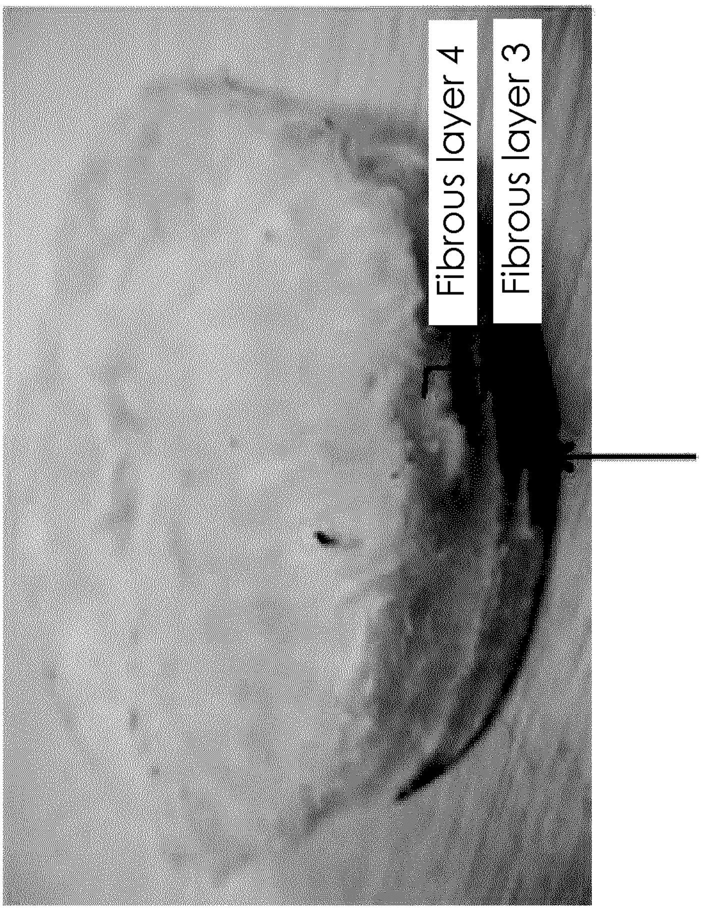

Fibrous layer 4
Fibrous layer 3
Aluminum film, substrate layer 2

Figure 7

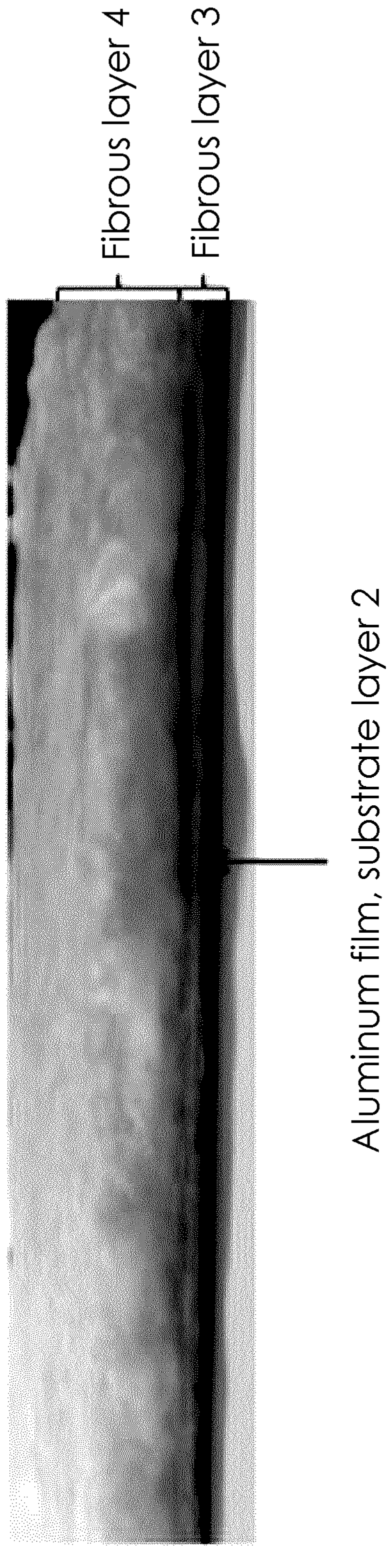

Fibrous layer 4
Fibrous layer 3
Aluminum film, substrate layer 2

Figure 8

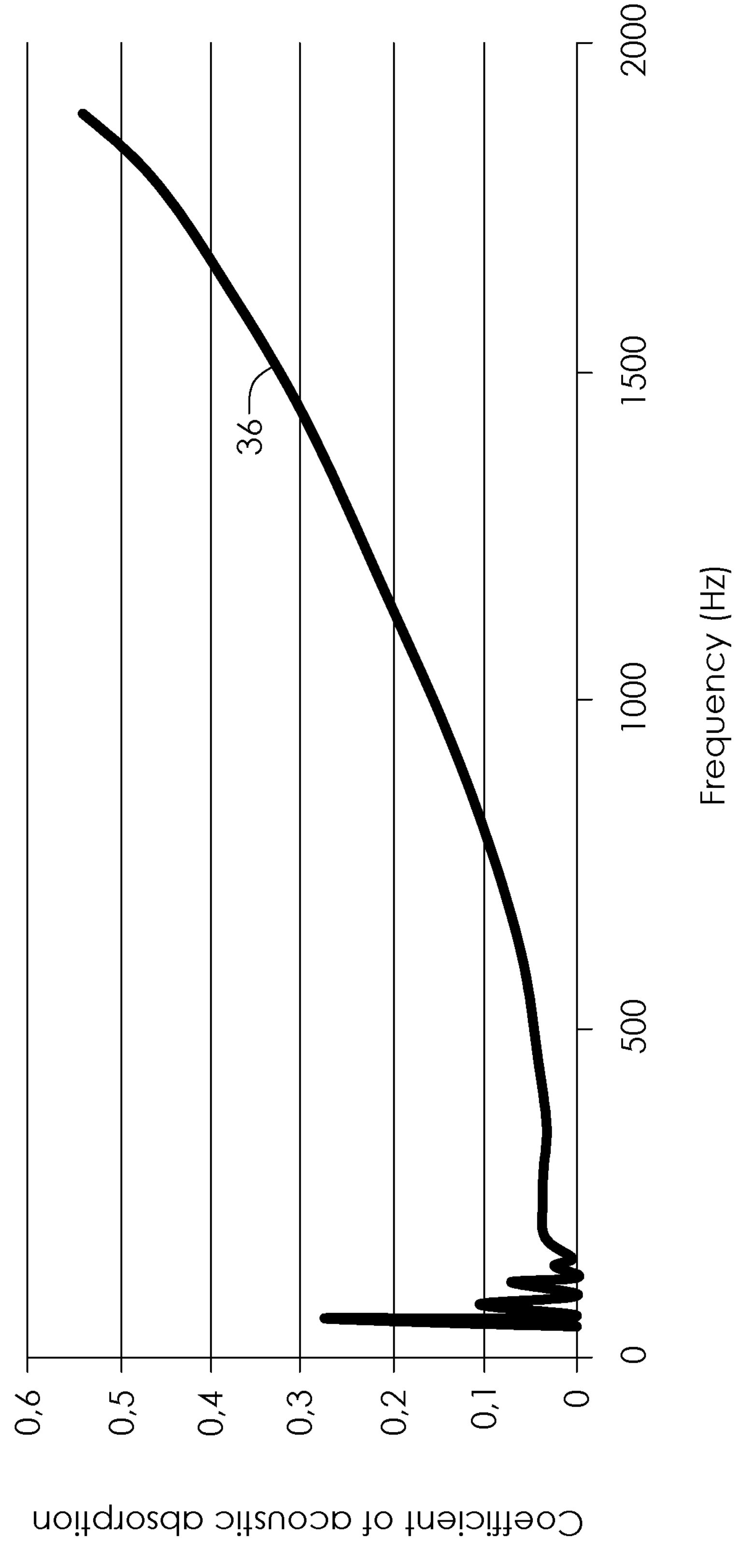
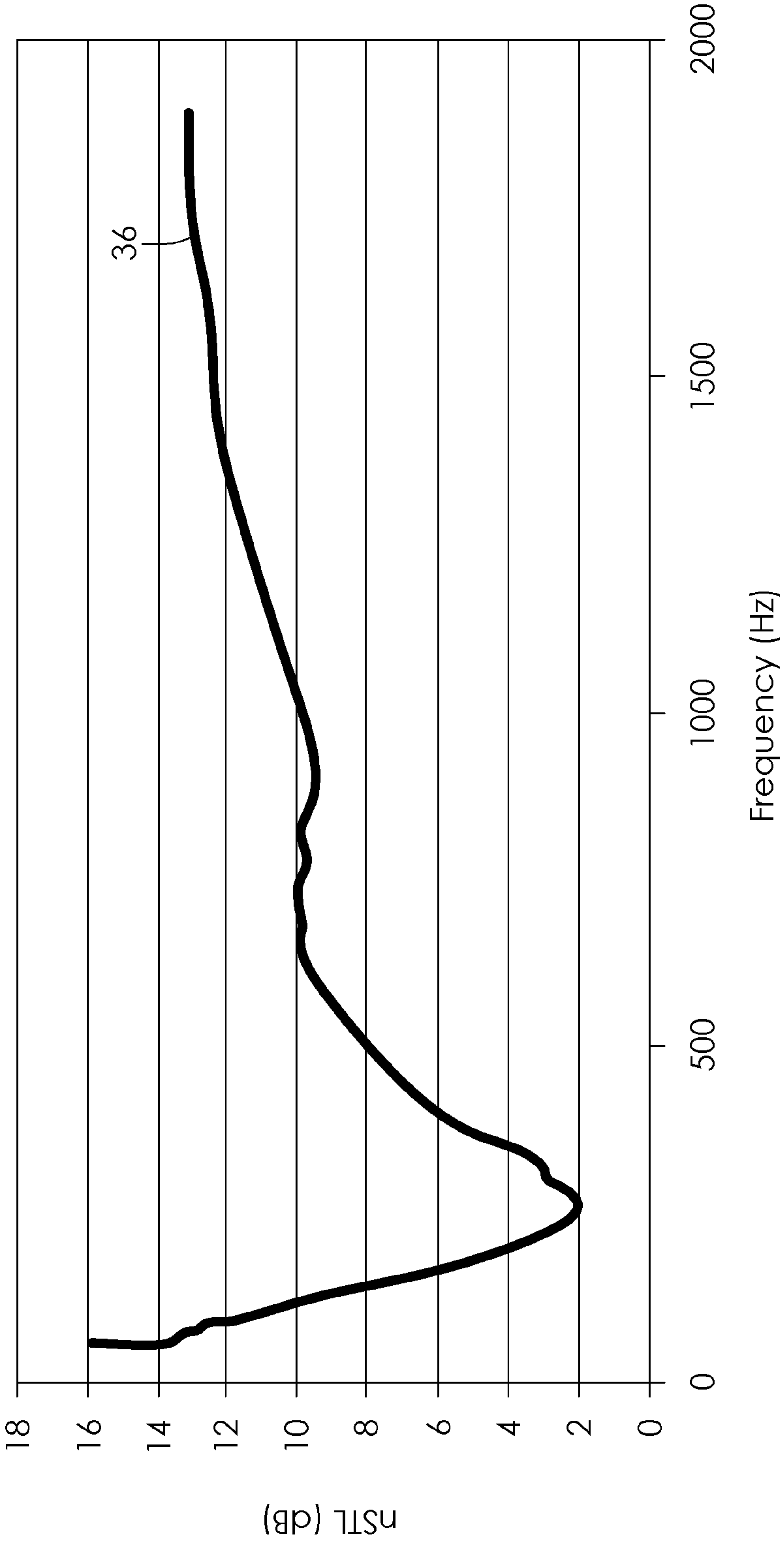

Coefficient of acoustic absorption
0,6
0,5
0,4
0,3
0,2
0,1
0
0
500
1000
1500
2000
Frequency (Hz)
36

Figure 9



nSTL (dB)
0
2
4
6
8
10
12
14
16
18
Frequency (Hz)
0
500
1000
1500
2000
36

Figure 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2014/050566

A. CLASSIFICATION OF SUBJECT MATTER
IPC: ***G10K 11/168*** (2006.01) , ***B32B 37/12*** (2006.01) , ***B32B 5/02*** (2006.01) , ***B32B 5/26*** (2006.01)

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)
IPC: G10K 11/168, B32B 37/12 , B32B 5/02, B32B 5/26

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

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
Questel; keywords: acoustic and absorption and weight and density and layer and "sound insulating" and ("hollow fiber" or "hollow fibers")
TotalPatent; keywords: acoustic and absorption and sound and (insulating or insulate) and (fibrous or fiber) and weight and density and layer and "sound insulating" and ("hollow fiber" or "hollow fibers")

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 6,669,265 B2 (Tilton et al.) 30 December 2003 (30-12-2003) FIG 3; col 4, line 56 to col 5, line 61 Whole document	1, 3-9, 19-26 2, 10-18
Y	JP 4167505 B2 (FUJIKOO) 15 October 2008 (15-10-2008) FIG 1; para [006], [0008], [0010]-[0013], [0034]	2, 10-11, 16-18
Y	US 2009/0242325 A1(Dellinger et al.) 1 October 2009 (01-10-2009) FIGs 1-6; para [0019]-[0022], [0025]	12-15, 27-31
Y	US 6,572,723 B1 (Tilton et al.) 3 June 2003 (03-06-2003) FIG 1a; col 4, lines14-17; col 5, lines 12-23	27-31

☐ Further documents are listed in the continuation of Box C.   ☑ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier application or patent but published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search	Date of mailing of the international search report
20 August 2014 (20-08-2014)	15 September 2014 (15-09-2014)

Name and mailing address of the ISA/CA	Authorized officer
Canadian Intellectual Property Office Place du Portage I, C114 - 1st Floor, Box PCT 50 Victoria Street Gatineau, Quebec K1A 0C9 Facsimile No.: 001-819-953-2476	Valeria Lambrache (819) 997-1203

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CA2014/050566

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		CA2444641A1	12 December 2002 (12-12-2002)
		CA2445060A1	12 December 2002 (12-12-2002)
		EP1294558A2	26 March 2003 (26-03-2003)
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		EP1401640A1	31 March 2004 (31-03-2004)
		EP1421232A2	26 May 2004 (26-05-2004)
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		MXPA03010234A	10 March 2004 (10-03-2004)
		MXPA03010863A	17 February 2004 (17-02-2004)
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		US2003003835A1	02 January 2003 (02-01-2003)
		US2004242109A9	02 December 2004 (02-12-2004)
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		WO0202302A2	10 January 2002 (10-01-2002)