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(54) **Title**: NONWOVEN PANEL AND METHOD OF CONSTRUCTION THEREOF

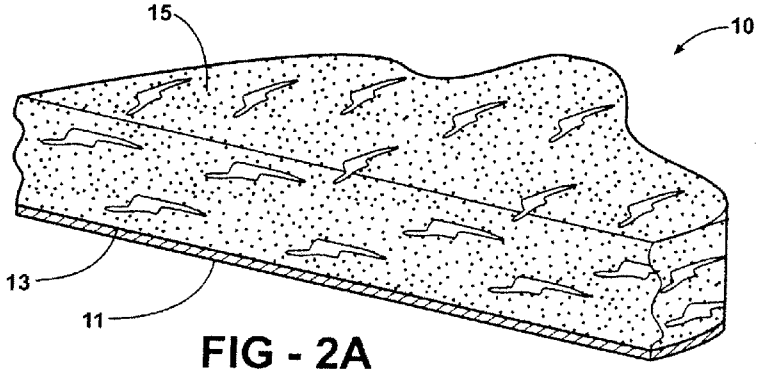

FIG - 2A

(57) **Abstract**: A reflective panel and method of construction thereof from post consumer mixed Asian cardboard for forming structural and/or acoustic and/or thermal panels is provided. The method includes providing post consumer mixed Asian cardboard and comminuting the cardboard into predetermined reduced sized pieces. Then, combining the reduced sized pieces with a heat bondable textile material to form a substantially homogenous mixture. Further, forming a web of the mixture of a predetermined thickness in a dry nonwoven webbing process. Then, heating the web to bond the heat bondable material with the reduced sized pieces to form a nonwoven sheet having opposite sides. Further, bonding at least one reflective layer to at least one of the opposite sides of the nonwoven sheet.

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NONWOVEN PANEL AND METHOD OF CONSTRUCTION THEREOF

BACKGROUND OF THE INVENTION

1. Technical Field

[0002] This invention relates generally to nonwoven panels and methods for their construction, and more particularly to acoustic, thermal and/or structural panels constructed at least partially from waste material constituents ordinarily not suitable for reprocessing, more particularly, a mixture including Asian cardboard.

2. Related Art

[0003] In order to reduce the costs associated with manufacturing nonwoven fabrics and materials and to minimize potentially negative affects on the environment, many consumer products are constructed using recycled constituents. For example, automobile manufacturers in the United States use recycled materials to construct nonwoven fabrics and materials having various uses, including sound absorption and/or insulation materials. Some reclaimed or recycled materials used to construct sound absorbing vehicle panels include fabric shoddy, such as, for example, cotton, polyester, nylon, or blends of recycled fabric fibers. Cotton shoddy is made from virgin or recycled fabric scraps that are combined and needled to form a nonwoven fabric. Another product constructed from recycled standard cardboard papers or fibers, used on a limited basis to absorb oils, is Ecco paper. In the process of constructing Ecco paper, the standard cardboard fibers are broken down using conventional wet recycling techniques, wherein constituent binder ingredients of the recycled cardboard are flushed into a waste stream, and the remaining fibers are combined with various additives.

[0004] U.S. commercial establishments and consumer product manufacturers, for example, automotive component parts and original equipment manufacturers, receive numerous shipments from various Asian countries, such as China and Korea, in boxes or containers constructed of low grade "Asian cardboard." The Asian cardboard has constituents of very short, very fine fibers from previously recycled pine cardboard, as well as bamboo and rice fibers. As such, attempts to recycle Asian cardboard into paper, cardboard or other structural panel products through the paper mill process has been met with failure, with the very fine constituents of the Asian cardboard being flushed through the screens or mesh used to carry pulp in the paper/cardboard manufacturing process into the environment via the resulting waste stream of the recycling process. Accordingly,

Asian cardboard is typically considered to be waste, and thus, is either sorted from standard cardboard at a relatively high labor cost and sent to landfills (during sorting, the Asian cardboard is readily identifiable from standard cardboard due to its relatively flimsy structure and its pale brown or greenish color) or the entire bale is scraped if there is more than 5% Asian cardboard mixed in a bale of recycled cardboard, also with a relatively high cost to both the product manufacturer and the environment.

SUMMARY OF THE INVENTION

[0005] According to one aspect of the invention, a method of constructing a reflective panel from post consumer mixed Asian cardboard is provided. The method includes providing post consumer mixed Asian cardboard and comminuting the cardboard into predetermined reduced sized pieces. Then, combining the reduced sized pieces with a heat bondable textile material to form a substantially homogenous mixture. Further, forming a web of the mixture of a predetermined thickness in a dry nonwoven webbing process. Then, heating the web to bond the heat bondable material with the reduced sized pieces to form a nonwoven sheet having opposite sides. Further, bonding at least one reflective layer to at least one of the opposite sides of the nonwoven sheet.

[0006] According to another aspect of the invention, a reflective panel is provided. The reflective panel includes a heat bondable textile material and an Asian cardboard material. The Asian cardboard material is comminuted and bonded with the heat bondable textile material to form a nonwoven sheet having opposite sides. At least one reflective layer is bonded to at least one of the sides of said nonwoven sheet.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] These and other aspects, features and advantages of the present invention will become more readily appreciated when considered in connection with the following detailed description of presently preferred embodiments and best mode, appended claims and accompanying drawings, in which:

[0008] Figure 1 is a perspective view of an exemplary nonwoven panel constructed in accordance with one presently preferred aspect of the invention;

[0009] Figures 2A-2D are enlarged cross-sectional views of different nonwoven panels of Figure 1;

[0010] Figure 3 is a process flow diagram illustrating an exemplary method of constructing a nonwoven material in accordance with one aspect of the invention; and

[0011] Figure 4-8 are graphs illustrating sound absorption characteristics of a nonwoven material constructed in accordance with the invention.

DETAILED DESCRIPTION OF PRESENTLY PREFERRED EMBODIMENTS

[0012] Referring in more detail to the drawings, Figure 1 illustrates a vehicle, by way of example and without limitation, having a nonwoven member, also referred to as panel 10, constructed in accordance with one aspect of the invention. The panel 10 can be configured for use in any number of applications, such as automotive, aircraft, aerospace, marine, and industrial, for example. The panel 10, aside from being capable of providing a formable structural member, whether by machine or hand, can be fabricated with noise damping or attenuation properties, thus, functioning as an acoustic panel. In addition, the panel 10 is constructed having at least one reflective layer 11 (Figure 2A) or more (Figure 2B) to reflect heat and/or to provide an increased strength and stiffness to the panel 10. Further the panel 10 can be constructed having fire retardant properties, if intended for use in extreme high temperature environments, such as near an exhaust system or within a vehicle engine compartment, for example. The panel 10 is constructed from mixed Asian cardboard and low temperature heat bondable fibers, with the processed cardboard materials being bonded in the form of the panel 10 by the low temperature, heat bondable textile fiber and/or other suitable binder materials. Further, fillers and filler fibers can be incorporated in the panel 10. Further yet, the panel 10 has the one or more layers 11, 11' bonded to one or both sides 13, 15. With the panel 10 being constructed at least in part from post consumer, reclaimed or recycled cardboard materials 12, the environment is benefited, such that the reclaimed cardboard is kept from being sent to landfills or from being incinerated.

[0013] The mixed recycled cardboard material 12 can be provided as any mixture of Asian (an inferior grade of cardboard commonly produced in Asian countries, e.g. China and Korea and shipped into the U.S., which is typically considered non-recycleable by various state environment agencies heretofore, such as in Connecticut, New Hampshire and Massachusetts) and standard cardboard material (that made from wood, such as pine, which is typical in the U.S). Because recyclers typically allow only 5% Asian cardboard mixed with the "Standard Cardboard", the primary focus is on cardboard batches

containing with between 5% and 100% Asian cardboard. This "Standard" and "Asian" cardboard mixture will hereafter be referred to as "mixed Asian cardboard". As such, a method of recycling cardboard materials for use in manufacturing vehicle components, in accordance with one aspect of the invention, negates the need to separate inferior, low-grade cardboard materials, including Asian cardboard, from higher grade cardboard, such as that manufactured in the U.S. Accordingly, piles, bundles, or mixtures of standard high grade cardboard material from cardboard containers can be readily recycled in combination with the Asian cardboard without concern of separating the two types of cardboard materials from one another. The content of the cardboard, whether mixed or 100% Asian, is preferably between about 25-99 weight percent of the total web weight, depending on the desired characteristics of the panel 10 being constructed. Generally, about 25% recycled material in a new product is needed in order to be considered a "Recycled" product.

[0014] The Asian cardboard is considered to be a low grade, non-recycleable cardboard due to its being constructed from inferior constituent ingredients, such as low quality recycled fibers, bamboo fibers, jute, rice fibers, and/or other scrap/waste materials. As such, Asian cardboard is typically considered to be a serious non-recycleable contaminant, whether on its own or if bailed or otherwise included in reclaimed post consumer cardboard loads. Accordingly, if Asian cardboard is bailed with standard U.S. cardboard, then the entire bail or load is typically considered to be non-recycleable waste (again, typically including a content of Asian cardboard above 5%). Asian cardboard can be distinguished from higher quality U.S. cardboard by its flimsiness and characteristic pale brown, yellow or greenish color. Accordingly, Asian cardboard is typically separated from higher quality U.S. cardboard, and sent to landfills, burned, or otherwise disposed.

[0015] The inability of Asian cardboard to be recycled stems from the constituent ingredients of the inferior fibers used in the construction of the Asian cardboard, which are generally very short and thus very weak. Given the relatively fine size of the fibers and other powdery ingredients in Asian cardboard, if the Asian cardboard is processed in known wet recycling processes along with standard cardboard having fibers of an increased length, the ingredients of the Asian cardboard get flushed through the screens and carried into the waste stream and/or plug and otherwise damage the recycling equipment. Accordingly, in accordance with the invention, the construction of the panel 10 is performed in a dry process, thereby allowing the utilization of the inferior Asian

cardboard along with the fibers having a length less than 0.2mm (referred to as "fines") in it's manufacture.

[0016] The heat bondable textile material can be provided, for example, as a low temperature melt polymeric material, such as fibers of polyethylene, PET or Nylon. It should be recognized that other low melt polymeric materials could be used, such as thermoplastic bi-component fibers whose outer sheath, such as polypropylene, for example, melts when heated above its melting point. This melted resin then fuses with the mixture of any textile fibers present and the cardboard fibers and with remaining binders from the recycled cardboard materials. As an example, the melting point of the outer portion of a PET low melt fiber may be approximately 110°C - 180°C as compared to the core melting at 250°C. Persons skilled in the art will recognize that other coatings or fillers and filler fibers may be used in place of low melt fibers to achieve the desired result, and further that the heat bondable material 14 can be used in combination with or replaced by a binder (for example, less low melt fiber can be used if a binder is used to stiffen the feel of the fabric). An SBR with a Tg of +41 is an example of a binder that can be used. Further, the heat bondable textile materials can be combined with other organic or inorganic fibers and/or coated with heat resistant or fire retardant (FR) coatings (Ammonium Sulfate, Ammonium Phosphate, or Boric Acid, for example) and/or coated with an anti-microbial coating (Polyphase 678, Rocima 200, or UF-15, for example) on at least one of the heat bondable textile materials or the recycled cardboard material. This is similar to the cellulose insulation industry where an FR treatment and a mildeweide are added to the paper during the fiberization process.

[0017] As shown in Figure 2A, the panel 10 can have a single reflective layer 11 bonded to one side 13, while an opposite side 15 can remain uncovered, thereby presenting exposed cardboard material 12. The reflective layer 11 can be provided having a material thickness as needed for the intended function. Generally, though relatively thin, the reflective layer 11 is either intended to function to reflect heat and/or to increase the structural strength and stiffness of the panel 10. The reflective layer 11 is shown as being provided as a thin, impervious sheet of metal, such as a sheet of foil, such as aluminum, for example. It should be recognized that materials other than aluminum can be used to form the reflective layer 11. In use, the side 13 covered by the reflective layer 11 is positioned to face a source of heat, such as an exhaust pipe, for example, while the opposite side remains uncovered, which provides an optimal surface for sound absorption.

The reflective layer 11 can be adhered and maintained as a generally flat sheet, or it can be processed to have an undulating, or otherwise upset surface configuration, such as in an embossing process. For example, as shown in Figure 2B, the panel 10 has one reflective layer 11 on one side of the panel and another reflective layer 11' on an opposite side of the panel. The reflective layer 11 is bonded and maintained in its generally flat configuration, while the opposite reflective layer 11' is embossed, either before or after being adhered to the sides of the cardboard sheet, thereby having a corrugated, or otherwise non-planar, undulating surface. The embossing provides the layer 11', and thus, the panel 10, with an increased strength and stiffness, which is useful in applications requiring the panel 10 to withstand loads and to provide structural support. Further, with the one or more reflective layers 11, 11' being metal, the resulting panel 10 is made formable, thereby allowing the panel 10 to be bent and maintained in a desired configuration for use, either prior to or during application. Accordingly, the panel 10 can be wrapped about a surface to be shielded with the metal layer 11, 11' maintaining the panel 10 in its formed configuration.

[0018] In accordance with another aspect of the invention, a method of manufacturing the acoustic, and/or thermal panels 10 is provided. The method includes providing the reclaimed or recycled cardboard materials 12, as discussed above, such as by reclaiming the cardboard materials from containers carrying goods shipped to a manufacturer, such as an automotive components manufacturer, for example. Then, comminuting the cardboard materials 12 into the desired size pieces and/or dry fibrous state, such as in a chopping, shredding, and/or grinding operation. It is contemplated that when the mixed Asian cardboard is being used, that the pieces be fiberized using a screen size between 3/32" and ½" when using the hammer-mill type method. This produces a similar sized fiber and nit of that in the blown insulation industry. Depending on the characteristics sought, such as acoustic damping or structural characteristics, the size of the comminuted pieces or nits can be altered. It has been found that by altering the size of the pieces, the acoustic absorption properties of the panels 10 changes. Using a hammer-mill to fiberize the cardboard, the cardboard particle size is determined by the size of the screen used. This screen size is not the actual size of the cardboard particles or nits that are formed. The actual size of the largest pieces is closer to half the screen size. However, much of the cardboard within a certain labeled size is also smaller than half the size of the screen size and includes particle sizes down to dust size (also called "fines"). Approximately one half the mass of the cardboard in each labeled size are "large" pieces (meaning half the screen

size) and the other half is smaller pieces with lot of dust. As shown in Figure 4, test samples containing 50% cardboard, 30% low-melt PET, 20% Shoddy with no coating or binder, show the correlations between cardboard particle size versus sound absorption values. Basically, the smaller the sized "nit" the higher the sound absorption for the insulation. The textile manufacturing process must also be taken into account as to what sized particles will run most efficiently and practically. This may change the final air-laid system depending on what sized fiber nit is determined to best suit the application, keeping in mind that using the most "dust" that is produced in the fiberizing system is the best environmental option which may also negatively affect the "dust-out" requirements. If using a hammer mill, the screen may be oriented in various directions or take on various shapes, including circular, vertical, or horizontal. If the ground/hammer-milled mixture will be combined with textile fibers, it is then fluffed to facilitate being mixed with the textile fibers.

[0019] Another aspect of the invention includes changing the percentage of cardboard used in the panel to customize the sound absorption curve of the final panel. Depending on what "filler" fiber is used, the cardboard may increase the sound absorption values or it may actually decrease the sound absorption values of the final panel. As shown in Figures 5 through 8, examples of how the absorption curves differ with different filler fibers when the amount of fiberized mixed cardboard is increased. Jute, recycled carpet, recycled shoddy, and recycled white PET fibers were all used for the filler fibers. In these particular tests, the amount of cardboard used was 25% and 50% of the total panel weight. These tests showed that the more fiberized mixed Asian cardboard percentage the higher the sound absorption within the frequency range tested for the Jute, recycled carpet, and recycled shoddy. The recycled white PET fibers showed lower sound absorption with the addition of more mixed Asian cardboard. This leads to the belief that the more mixed Asian cardboard in the lower performing fibers, the better the absorption values and the more mixed Asian cardboard in the higher performing fibers, the worse the absorption values of the nonwoven. However, this is not a hard and fast rule because the size of the nits/dust will also affect the absorption values. These tests used a 3/8" screened hammer-milled product. Because of some preliminary testing, there is reason to believe, a high percentage of very small nit mixed Asian cardboard along with the fines, can produce a panel with superior sound absorption as compared to PET fibers. By changing the percentage of mixed Asian cardboard used in the panel along with the size of the nits, the

panel can be engineered to have any absorption curve required by the application while reducing the waste stream.

[0020] The hammer-milled fibers and fragments of the cardboard 12 are next blended with any desired recycled or virgin textile fibers, which may include the low-melt fibers 14 or other binder materials, as mentioned. The proportion of the hammer-milled fibers and fragments of cardboard 12 to textile fibers 14 can be varied between about 25 to 99 weight percent (wt%) of the finished panel 10. The proportion of low-melt fibers 14 to recycled cardboard fibers 12 can be varied as best suited for the intended application of the panel 10, but the low melt fibers 14, if any, and are generally provided to be between about 5% to 45 wt% of the panel 10.

[0021] The mixture is then subjected to a nonwoven webbing process, which may be performed, for example, on a Rando machine. The webbing process forms a homogenously mixed or substantially homogenously mixed fiber/paper mat or web, with the fibers of the cardboard 12 being randomly oriented. The web is then run through a heat bonding oven to melt the low melt fibers to form a nonwoven sheet, or if desired for the intended application, the web can be fed through a needle loom to be needle punched. The heating process may be performed by passing the web into or through any suitable oven, or by feeding it over and/or through at least one or more heated rollers. The resulting bonded nonwoven sheet may be cooled using at least one roller, such as, for example, by being passed over a cooling roller and/or by being passed between two or more cooling rollers after heating to control its thickness and density. If needle punching the web, a thin nonwoven that resists tearing, or a scrim layer, may be applied to one or both sides 11, 11' of the web to prevent any of the cardboard fibers or pieces from building up on the needles, as build-up of cardboard on the needles is undesirable and may cause them to break. The scrim layer also serves as a "net" to control dust from being released from the web. Reemay fabric is one example of a scrim that can be used for this purpose. The scrim or protective layer of fabric may additionally add strength to the web and facilitate the webbing process. The web can also be coated with a binder that further binds all of the fibers and paper in place and prevents it from forming dust (SBR, Acrylic, or Latex binders are some examples of what can be used). Flame retardant additives can also be added to the coating. Upon applying the binder, it can be dried and cured.

[0022] The one or more reflective layers 11, 11' are bonded to the side or sides 13, 15 of the nonwoven sheet. The reflective layers 11, 11' can be bonded using any suitable

adhesive, and further, can be bonded to the web while applying the heat to the web to melt the low melt constituents within the web. Accordingly, the low melt material can be used, in part or whole, to bond the reflective layers 11, 11' to the web. In addition, if an embossed reflective layer 11' is used, the embossing can be performed prior to attaching the layer 11' to the web (Figure 2B), or after being bonded to the nonwoven sheet (Figure 2C), as desired. If embossed before bonding, then insulating air pockets are formed between the layer 11 and the nonwoven sheet, and if after bonding, the cardboard material tends to fill the embossed undulations, thereby making the finished panel 10 more dense.

[0023] The resulting nonwoven panels 10 may have a thin nonwoven fabric or scrim layer attached or bonded to the side of the panel not having a reflective layer, or a scrim layer 17 may be sandwiched between a plural of separate panels 10 laminated to one another (Figure 2D). The scrim layer can be bonded using a suitable heat resistant adhesive, a low-melt blend of fibers within the scrim, or it can be attached via stitch-bonding. Of course, it should be recognized that the plural of panels 10, such as shown in Figure 2D, can be laminated without using the scrim layer 17, if desired.

[0024] The nonwoven panels 10 constructed in accordance with the invention are suitable for use in a wide variety of applications, including acoustic panels and thermal panels. Such applications more specifically include the acoustic panels between the finished interior panel and the steel of the car, including, the headliner, side door panels, the trunk, and under the carpet, for example. Extreme thermal applications include, by way of example and without limitation, heat shields, such as adjacent exhaust system components or within an engine compartment.

[0025] The finished panel 10 can then be cut into desired lengths and shapes, and further bent or hand formed to take on the desired configuration for the intended application.

[0026] Many modifications and variations of the present invention are possible in light of the above teachings. It is, therefore, to be understood that the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A method of constructing a reflective panel from post consumer mixed Asian cardboard, said panel being useful for forming structural and/or acoustic and/or thermal panels, said method comprising:

providing post consumer mixed Asian cardboard;

comminuting said cardboard into predetermined reduced sized pieces;

combining said reduced sized pieces with a heat bondable textile material to form a substantially homogenous mixture;

forming a web of said mixture of a predetermined thickness in a dry nonwoven webbing process;

heating said web to bond said heat bondable material with said reduced sized pieces to form a nonwoven sheet having opposite sides; and

bonding at least one reflective layer to at least one of said opposite sides.

2. The method of claim 1 further including providing at least a portion of said cardboard having at least 5% Asian cardboard up to 100% Asian cardboard.

3. The method of claim 1 further including combining filler fiber in the substantially homogenous mixture and controlling the percent content of the cardboard relative to the heat bondable textile material and the filler fiber to achieve a desired acoustic performance characteristic in said nonwoven sheet material.

4. The method of claim 1 further including providing said heat bondable textile material as a polymeric material.

5. The method of claim 1 further including using at least one heated roller to perform the heating step.

6. The method of claim 1 further including adding a flame retardant constituent to said mixture.

7. The method of claim 1 further including adding an anti-microbial constituent to said mixture.

8. The method of claim 1 further including cooling said nonwoven sheet with using at least one cooling roller after the heating step.

10. The method of claim 1 further including bonding at least one reflective layer to both of said opposite sides.

11. The method of claim 10 further including increasing the structural stiffness of at least one of said reflective layers by embossing said at least one reflective layer.

12. The method of claim 1 further including providing at least one of said reflective layer as a foil layer.

13. The method of claim 12 further including providing at least one of said reflective layer as a sheet of aluminum.

14. The method of claim 1 further including performing the bonding during the heating step.

15. The method of claim 14 further including bonding the at least one reflective layer to the nonwoven sheet using the heat bondable material.

16. The method of claim 1 further including laminating a plural of said nonwoven sheets to one another.

17. The method of claim 16 further including bonding a reflective layer to each exposed opposite side of the laminated nonwoven sheets.

18. A reflective panel, comprising:
a heat bondable textile material;

a recycled post consumer mixed Asian cardboard material, said recycled cardboard material being comminuted and bonded with said heat bondable textile material to form a nonwoven sheet having opposite sides; and

at least one reflective layer bonded to at least one of said sides of said nonwoven sheet.

19. The reflective panel of claim 18 wherein said mixed Asian cardboard material comprises at least 25 weight percent of said reflective panel.

20. The reflective panel of claim 18 further including a flame retardant added to said nonwoven sheet.

21. The reflective panel of claim 18 further including an anti-microbial added to said nonwoven sheet.

22. The reflective panel of claim 18 wherein a reflective layer is bonded to both of said opposite sides.

23. The reflective panel of claim 22 wherein at least one of said reflective layers is embossed.

24. The reflective panel of claim 18 wherein said reflective layer is a foil layer.

25. The reflective panel of claim 24 wherein said foil layer is aluminum.

26. The reflective panel of claim 18 wherein a plural of said nonwoven sheets are laminated to one another.

27. The reflective layer of claim 26 wherein a reflective layer is bonded to exposed opposite sides of the laminated nonwoven sheets.

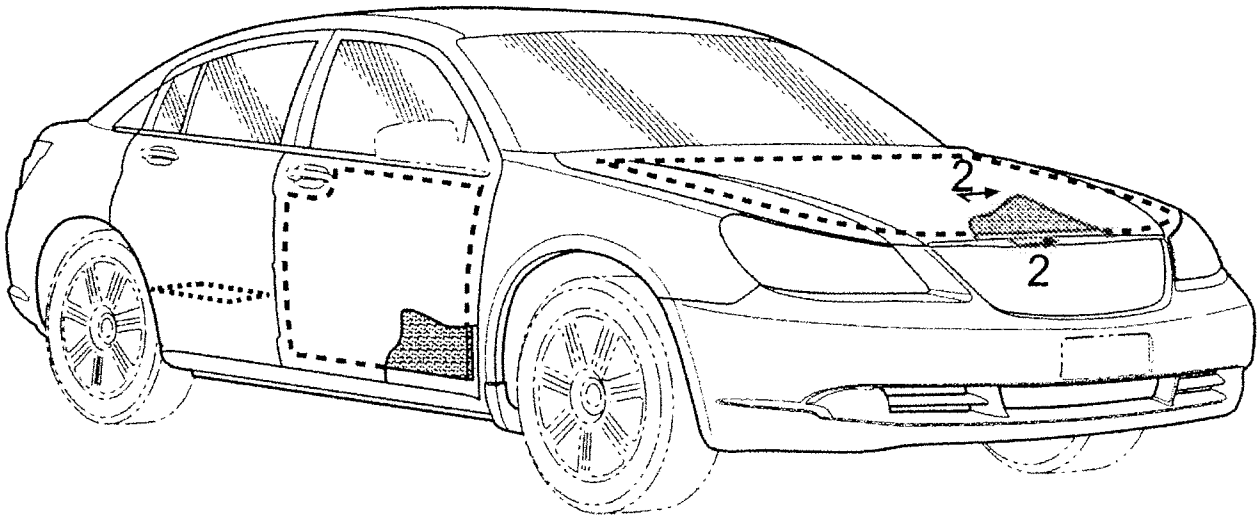


FIG - 1

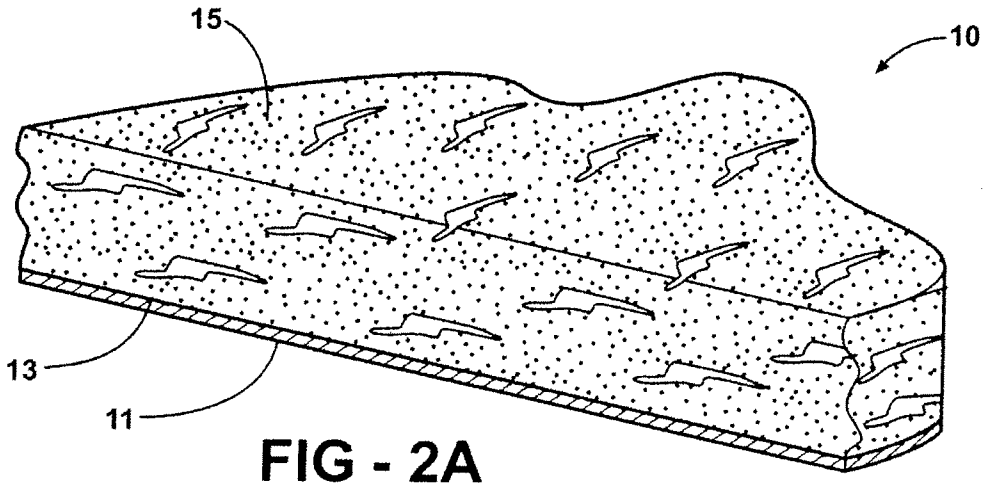


FIG - 2A

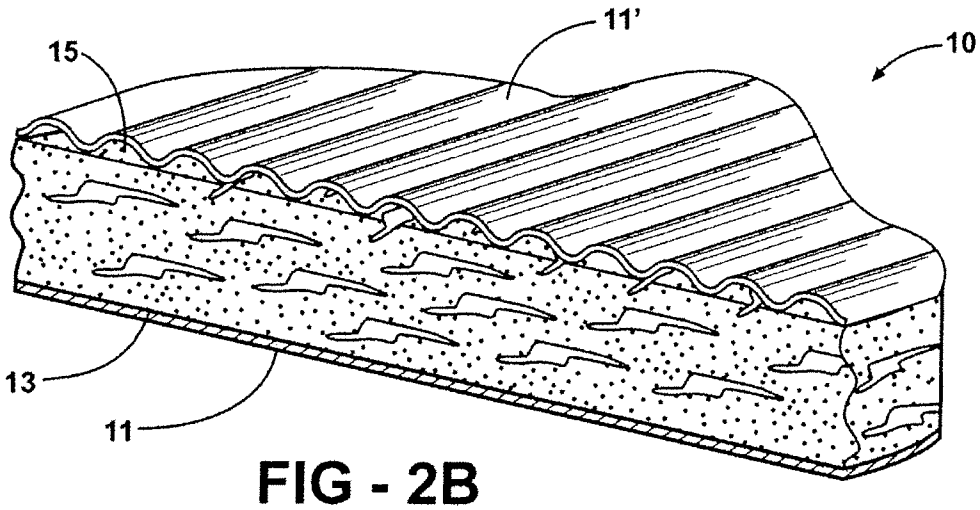
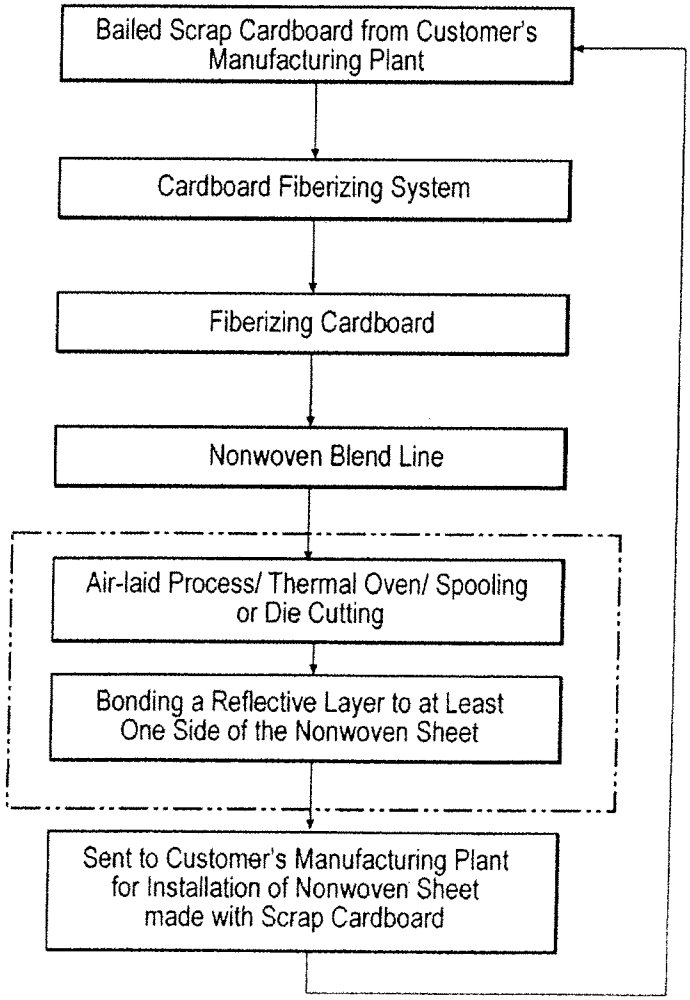

11'
10
15
13
11

FIG - 2B

FIG - 3


Bailed Scrap Cardboard from Customer's Manufacturing Plant
Cardboard Fiberizing System
Fiberizing Cardboard
Nonwoven Blend Line
Air-laid Process/ Thermal Oven/ Spooling or Die Cutting
Bonding a Reflective Layer to at Least One Side of the Nonwoven Sheet
Sent to Customer's Manufacturing Plant for Installation of Nonwoven Sheet made with Scrap Cardboard

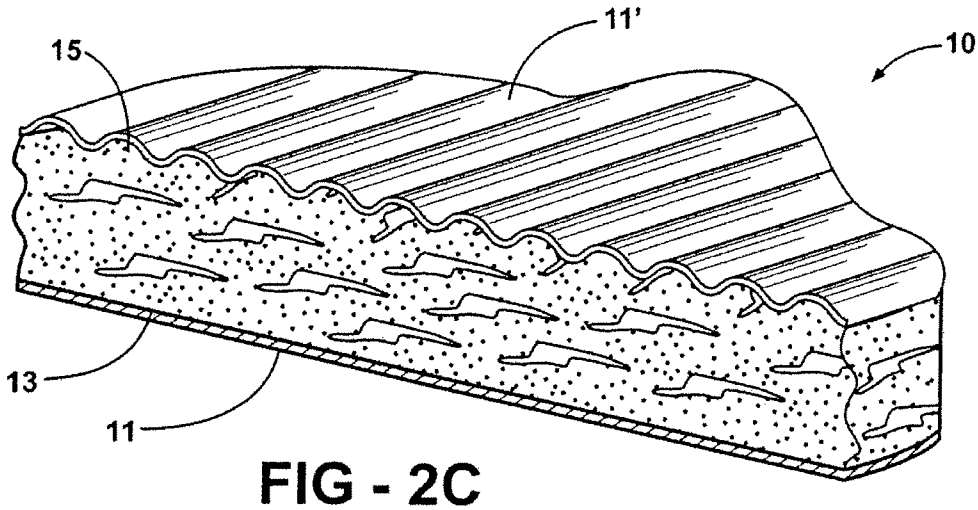


FIG - 2C

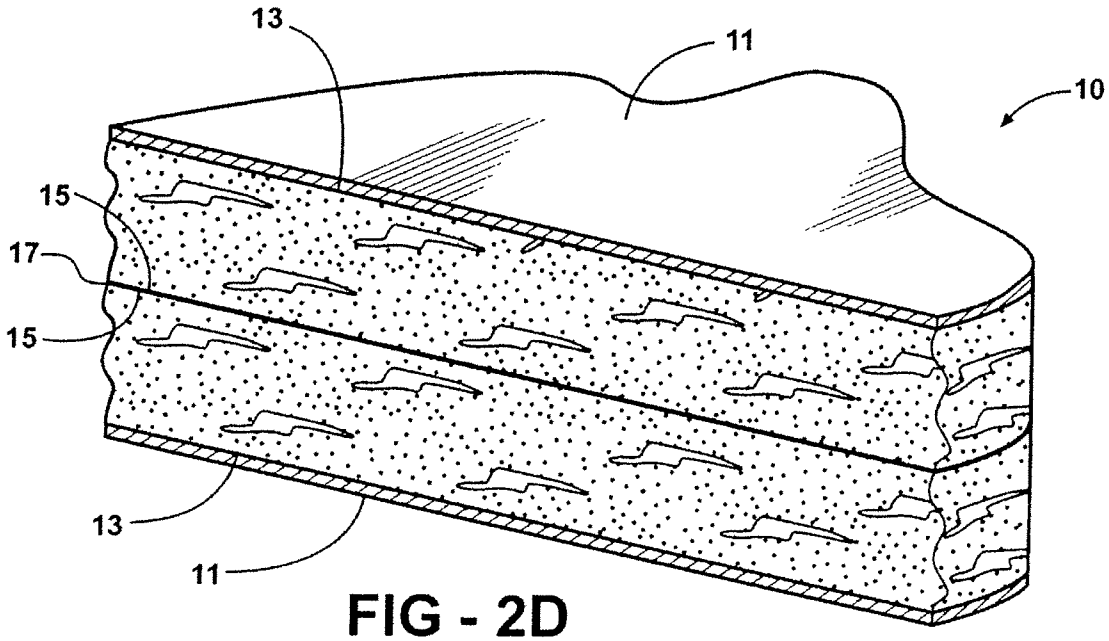


FIG - 2D

FIG - 4

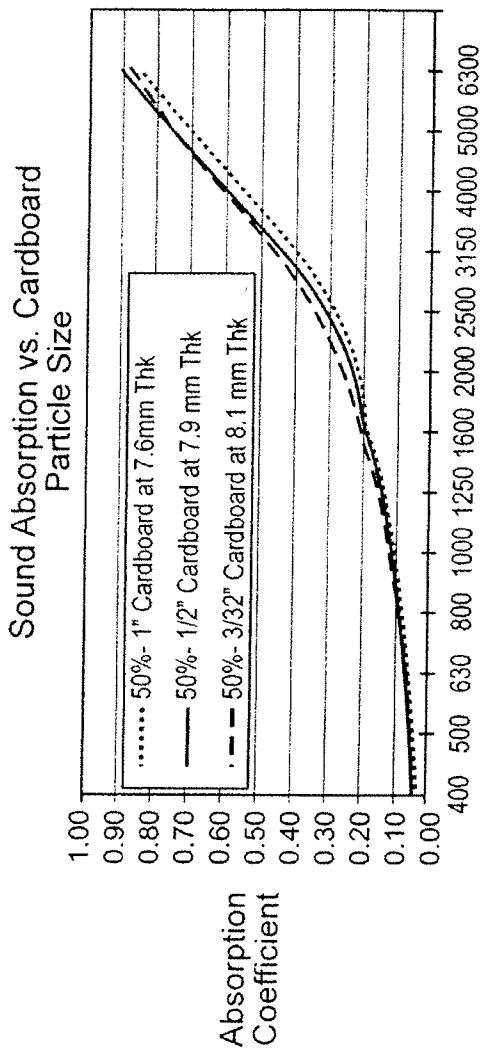

Sound Absorption vs. Cardboard Particle Size
50%- 1" Cardboard at 7.6mm Thk
50%- 1/2" Cardboard at 7.9 mm Thk
50%- 3/32" Cardboard at 8.1 mm Thk
Absorption Coefficient
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
400 500 630 800 1000 1250 1600 2000 2500 3150 4000 5000 6300
Frequency (Hz)

FIG - 5

Sound Absorption of Green Nonwoven-Carpet Fiber
25% Cardboard . 50% Cardboard
4FA-30mm-4.88opsf (50% Cardboard /20% Carpet- Foamed)
3FA-30mm-4.49opsf (25% Cardboard /45% Carpet- Foamed)
Absorption Coefficient
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
100
1000
10000
Frequency (Hz)

FIG - 6

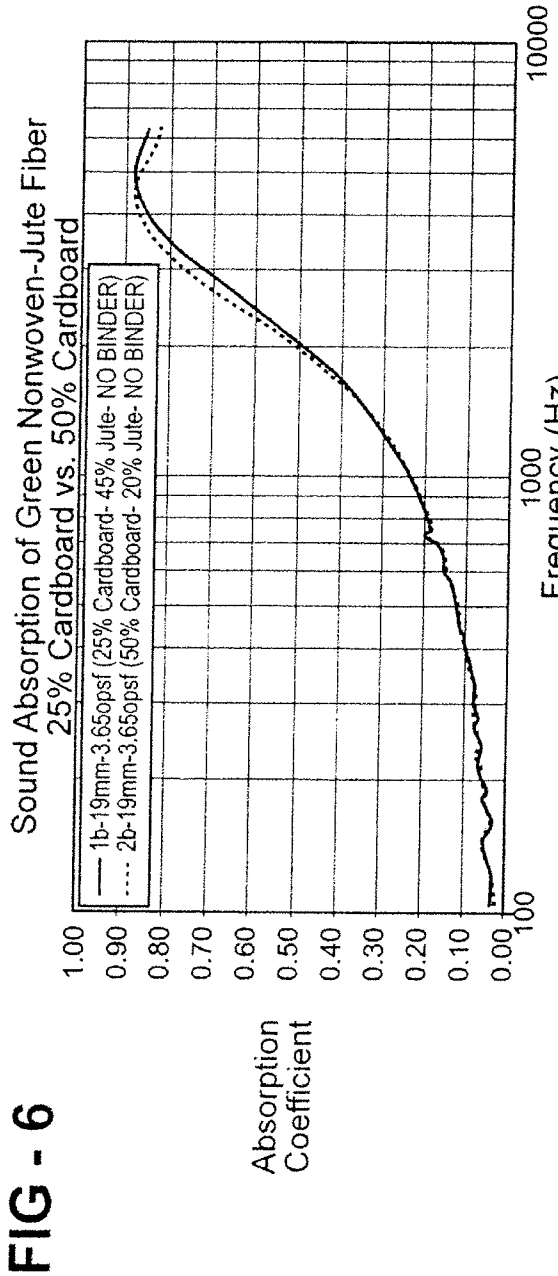
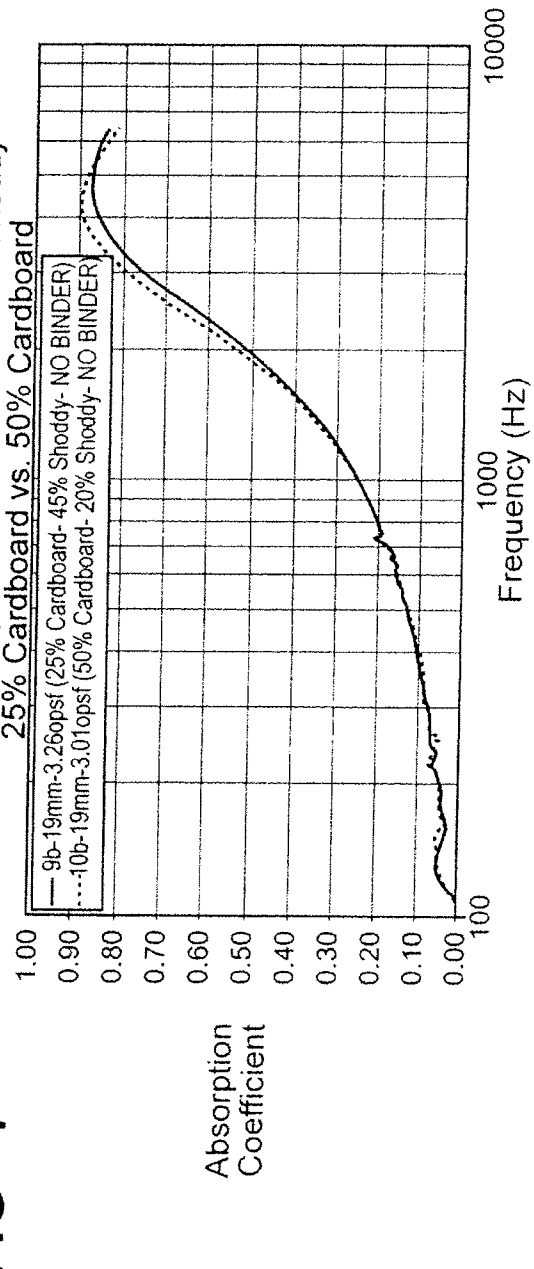

Sound Absorption of Green Nonwoven-Jute Fiber
25% Cardboard vs. 50% Cardboard
1b-19mm-3.65opsf (25% Cardboard- 45% Jute- NO BINDER)
2b-19mm-3.65opsf (50% Cardboard- 20% Jute- NO BINDER)
Absorption Coefficient
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
100
1000
10000
Frequency (Hz)

FIG - 7


Sound Absorption of Green Nonwoven-Shoddy
25% Cardboard vs. 50% Cardboard
9b-19mm-3.26opsf (25% Cardboard- 45% Shoddy- NO BINDER)
10b-19mm-3.01opsf (50% Cardboard- 20% Shoddy- NO BINDER)
Absorption Coefficient
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
100
1000
10000
Frequency (Hz)

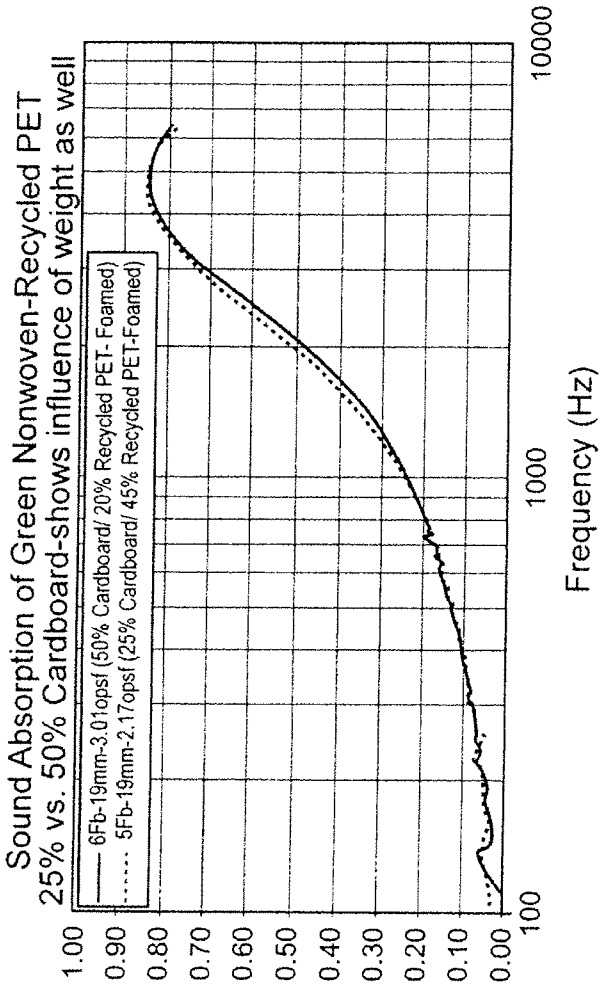

Sound Absorption of Green Nonwoven-Recycled PET
25% vs. 50% Cardboard-shows influence of weight as well
6Fb-19mm-3.01opsf (50% Cardboard/ 20% Recycled PET- Foamed)
5Fb-19mm-2.17opsf (25% Cardboard/ 45% Recycled PET-Foamed)
Absorption Coefficient
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
100
1000
10000
Frequency (Hz)

FIG - 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2012/026229

A. CLASSIFICATION OF SUBJECT MATTER
INV. D04H1/541 D04H1/4274 B32B5/26 B32B29/02 D04H1/4242
D04H1/425 B32B3/30 B32B15/14 B32B15/20 B32B5/02
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)
D04H B32B B60R

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 practicable, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2008/086458 A1 (FEDERAL MOGUL POWERTRAIN [US]; GLADFELTER HARRY F [US]; FOY CHRISTOPHE) 17 July 2008 (2008-07-17) paragraph [0026]; claims	1-27
Y	WO 2010/151627 A2 (FEDERAL MOGUL POWERTRAIN INC [US]; GLADFELTER HARRY F [US]; FOY CHRIST) 29 December 2010 (2010-12-29) paragraphs [0003], [0014], [0034]; claims 6,7,13,19,20; figure 4	1-27
A	WO 2005/110735 A2 (FEDERAL MOGUL POWERTRAIN INC [US]; FRYBERGER SAMUEL B JR [US]; SELLIS) 24 November 2005 (2005-11-24) page 1, lines 18-26 page 2, lines 23-28	1-27

☐ 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 application or patent but published on or after the international filing date

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"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

"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

"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

"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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 May 2012	30/05/2012

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2012/026229

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		WO 2005110735 A2	24-11-2005