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(54) **SOUND ABSORBING ASSEMBLY**

(57) There is provided a sound absorbing assembly (10), comprising:
- a support plate (30); and
- a woven or knitted fabric top layer (20) which is directly glued to the room facing planar side (35) of the support

plate (30) and which consists of a woven fabric. The fabric top layer thickness (22) of the woven or knitted top layer (20) is in the range of 1/7 to 1/12 of the support plate thickness (32).

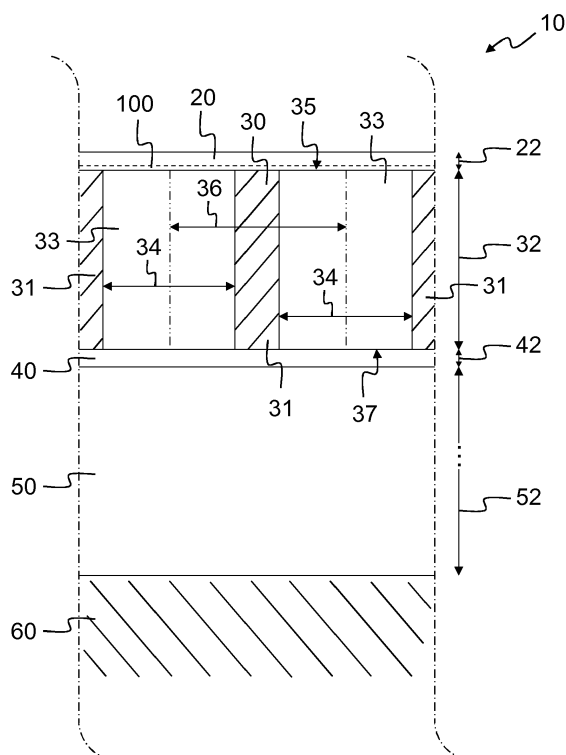


Fig. 1

Description

Field of the Invention

[0001] The present invention generally relates to a sound absorbing assembly and a method of manufacturing such a sound absorbing assembly. More specifically it relates to sound absorbing assemblies for use as for example plate shaped constructional elements, also referred to as building panels, ceiling panels, wall panels, partition panels etc.

Background of the Invention

[0002] Such a sound absorbing assembly is for example known from DE19839973. It discloses a sound absorbing assembly for use as a plate-shaped constructional element. The sound absorbing assembly comprises a support plate structure formed by a perforated plate approximately 6 to 30 mm thick made of a solid material such as metal, wood, wood chip board, Medium Density Fibreboard, pressboard, synthetic material or gypsum. This support plate structure comprises a pattern of support plate holes or a grating having a hole area fraction of 10-90%. The support plate holes in the support plate structure are relatively large, for example in the range of 2mm to 30mm. The sound absorbing assembly further comprises a micro-perforated sheet or thin plate disposed on one of the plate surfaces of the support plate structure. The micro-perforated sheet or thin plate comprises micro-holes having diameters smaller than 2 mm and a hole area fraction smaller than 4% of the total area. It is known from DE19839973 that the support plate holes and micro-holes cooperate to form a Helmholtz resonator structure.

[0003] DE19839973 teaches that, when using a non-woven material or tissue with a suitable flow resistance as a porous layer placed or stretched on one side of the perforated support plate structure with the large support plate holes, as shown in Figure 4 of DE19839973. According to DE19839973 this presents the disadvantage, that this non-woven material or tissues will be easily soiled when placed at the side facing of the room to be attenuated, and additionally the hole pattern and/or the frame of the support plate holes remains also visible. Therefore according to DE19839973 it is essential to make use of micro-perforated sheet, which is not made of a tissue or non-woven material on top of the support plate structure.

[0004] However such a micro-perforated sheet, which is for example manufactured as a high-pressure laminate or HPL, for example on top of a support plate structure manufactured as a medium-density fibreboard or MDF, even when provided with relatively small micro-perforations, in the form of holes or slots, leaves a regular and distinct repetitive pattern that is easily visible. Additionally drilling or milling holes or slots in such high quality materials is an operation that requires high performance and

high precision tools in order not to cause damage to the area immediately surrounding the micro-perforations. This limits the efficiency and increases the cost of manufacturing such a sound absorbing assembly.

[0005] A manufacturing process for a sound absorbing assembly in which a porous fabric is glued on top of rigid panel body with apertures. The pores of the fabric being substantially smaller than the apertures in the panel body. In order to allow for a suitable airflow through the fabric to the apertures in the panel body the glue is applied by means of a nozzle in a convoluting pattern surrounding these apertures. Such a complicated glue application process limits the efficiency and increases the cost of the manufacturing process for such a sound absorbing assembly.

[0006] Therefore there still exists a need for a simpler, robust, more performant sound absorbing assembly that overcomes the abovementioned problems, and which can be manufactured more efficiently.

Summary of the Invention

[0007] According to a first aspect of the invention there is provided a sound absorbing assembly, comprising:

- a support plate comprising:
 - a support plate thickness, between its room facing planar side and its opposing, wall facing planar side, in the range of 5mm to 30mm;
 - a plurality of support plate openings extending through the support plate from its room facing planar side to its wall facing planar side, comprising an opening width in the range of 4mm to 12mm, and a centre-to-centre distance in the range of 110% to 500% of the opening width; and
 - a fabric top layer which is directly glued to the room facing planar side of the support plate and which consists of a woven or knitted fabric;
- CHARACTERIZED IN THAT
the fabric top layer thickness of the fabric top layer is in the range of 1/7 to 1/12 of the support plate thickness.

[0008] In this way, surprisingly, improved sound absorbing values are obtained with respect to comparable sound absorbing assemblies making use of a micro-perforated sheet or thin plate comprises micro-holes as top layer. In this specific range of woven top layer thickness the pores of the woven fabric provide for an optimized Helmholtz-resonator like effect. In addition to the Helmholtz-resonator like effect, also the more irregular structure of the woven fabric and its yarns, when compared to a planar micro-perforated sheet provides for a more optimized dispersion and attenuation of the sound pressure waves. Additionally the visual appearance of the sound absorbing panel is improved as the pores of the

woven top layer do not result in a distinctive repetitive pattern, and this specific range for the woven top layer thickness ensures that the support plate openings and/or the frame of the support plate are no longer clearly visible when the sound absorbing assembly is mounted to a wall, ceiling or other suitable surface of a room. Similar advantages could also be achieved by means of knitted fabric top layer with the same range for the ratio of the knitted fabric top layer thickness with respect to the support plate thickness.

[0009] According to an embodiment there is provided a sound absorbing assembly, characterised in that:

- the support plate thickness is in the range of 6mm to 12mm; and
- the woven top layer thickness of the woven top layer is in the range of 1/8 to 1/10 of the support plate thickness.

[0010] In this way the Helmholtz resonator like effect of the support plate and the woven top layer is further optimized leading to optimized sound attenuation values. Alternatively a knitted top layer with a knitted top layer thickness of the fabric top layer in the range of 1/8 to 1/10 of the support plate thickness could be provided.

[0011] According to a further embodiment there is provided a sound absorbing assembly, characterised in that the woven fabric top layer comprises yarns with a thickness in the range of 50% to 120%, preferably 80% to 100% of the woven top layer thickness.

[0012] In this way a suitable the woven fabric top layer will comprise a suitable percentage of holes and sufficient undulation at the level of the warp yarns and weft yarns in order to achieve an improved sound attenuation effect. It is clear that with thickness of the yarn of the woven fabric top layer, there is referred to the dimension of the cross section of the yarn. For example in the case of a mono-filament yarn with a circular cross-section the thickness of the yarn refers to the diameter of the yarn. However in example where, the cross-section of the yarn has an alternative cross section, such that, when woven into the woven fabric of the woven fabric top layer the size of the cross-section of the yarn along the direction transverse to the plane of the woven fabric diverges considerably of the size of this cross section along the direction of the plan of the woven fabric, the thickness of the yarn refers to the size of the cross-section of the yarn generally transverses to the plane of the woven fabric.

[0013] Alternatively a knitted fabric top layer could be provided and preferably the yarns have a similar ratio for their thickness with respect to the knitted top layer thickness as similarly as with a woven fabric then a suitable percentage of holes and sufficient undulation at the level of the knitted yarns in order to achieve an improved sound attenuation effect.

[0014] According to a further embodiment there is provided a sound absorbing assembly, characterised in that the yarns comprise a mono-filament yarn. Such as for

example:

- a mono-filament yarn comprising a coating, such as for example a mono-filament glass yarn comprising a co-extruded polymer coating;
- a mono-filament polymer yarn;
- a mono-filament glass fibre yarn; or
- any other suitable mono-filament yarn.

[0015] Such mono-filament yarns ensure a good structural stability for the woven fabric top layer and additionally ensure an optimal percentage of holes and sufficient undulation at the level of the warp yarns and weft yarns in order to achieve a sound attenuation effect.

[0016] According to a further embodiment there is provided a sound absorbing assembly, characterised in that the yarns, comprise one or more of the following:

- a yarn comprising a mono-filament glass fibre core and at least one coating comprising polyvinyl chloride or polyethylene or any other suitable polymer or combination thereof;
- a filament yarn, preferably a mono-filament synthetic yarn, such as for example a mono-filament yarn comprising at least one suitable polymer or combination of polymers, such as for example polyvinyl-chloride, a polyester;
- a filament glass fibre yarn, preferably a mono-filament glass fibre yarn.

[0017] Although in general suitable spun or filament natural or synthetic yarns, such as for example multi-filament synthetic yarns, multi-filament glass fibre yarns, cotton yarns, wool yarns, etc. are possible, the specific yarns mentioned above allow for a sound absorbing assembly comprising a top layer that has an excellent product stability, a good moisture resistance, a good impact resistance, is scratch proof, shock proof, washable, etc. is realized comprising a simple and robust structure and improved sound absorbing parameters.

[0018] According to a further embodiment there is provided a sound absorbing assembly, characterised in that the woven top layer comprises a percentage of holes in the range of 0,5% to 7%, preferably in the range of 1 % to 5%.

[0019] In this way the Helmholtz-resonator like effect of the support plate openings in the support plate and the openings in between the warp and weft yarns of the woven top layer is further optimized leading to optimized sound attenuation values.

[0020] According to a further embodiment there is provided a sound absorbing assembly, characterised in that the woven top layer comprises a weaving pattern comprising a density in the range of 5 to 12, preferably 6 to 10, warp yarns and or weft yarns per centimetre.

[0021] In this way, a simple and robust woven top layer can be realized that contributes to optimal acoustic properties of the sound absorbing assembly as it comprises

a sufficient percentage of holes and a sufficient level of undulations of the yarns.

[0022] According to a further embodiment there is provided a sound absorbing assembly, characterised in that the sound absorbing assembly further comprises a wall cavity layer in between the wall facing planar side of the support plate and the wall, when mounted, the wall cavity layer thickness being in the range of 15mm to 70mm, preferably in the range of 18mm to 55mm.

[0023] This wall cavity allows for an optimal amount of further sound damping material to be placed in between the wall facing planar side of the support plate and the wall.

[0024] According to a further embodiment there is provided a sound absorbing assembly, characterised in that the wall cavity layer comprises one or more of the following:

- a mineral wool;
- a synthetic wool, such as for example a suitable polymer wool, for example a polyester wool with a density in the range of 300g/m² to 750g/m²
- a synthetic foam, for example a synthetic foam comprising melamine, polyethylene, poly-urethane, etc., and in that the support plate comprises one or more of the following:
 - a medium-density fibreboard plate;
 - a gypsum plate.

[0025] In this way a sound absorbing assembly comprising a Weighted Sound Absorption Coefficient in accordance with the ISO 11654 standard, also referred to as Alpha-W, of 0,7 or more, or even 0,9 or more can be realized for a sound absorbing assembly with a limited support plate thickness of only for example 8mm.

[0026] The use of synthetic wool or foam preferably allows to apply it already to the wall facing side of the sound absorbing assembly during manufacturing, which allows for a more efficient mounting operation.

[0027] According to a further embodiment there is provided a sound absorbing assembly, characterised in that the sound absorbing assembly further comprises a backing layer, the backing layer thickness being in the range of 0,1mm to 5mm, preferably in the range of 0,2mm to 2mm.

[0028] In this way the acoustical parameters of the sound absorbing assembly are still further improved.

[0029] According to a further embodiment there is provided a sound absorbing assembly, characterised in that the backing layer comprises a non-woven tissue, preferably a non-woven tissue comprising glass fibres with a weight in the range of 50g/m² to 75g/m² and a fibre diameter in the range of 7µm to 15µm.

[0030] Such a non-wove tissue can perform its acoustic function at the wall facing side of the support plate where it is no longer visible and where it can be easily applied.

[0031] According to a further embodiment there is provided a sound absorbing assembly, characterised in that the woven fabric top layer which is directly glued to the room facing planar side of the support plate by means of a glue layer of which the glue layer thickness is in the range of 10% to 30% of the woven top layer thickness.

[0032] In this way an optimal bonding of the woven top layer is assured while the risk of the glue layer filling up the pores of the top layer fabric, thereby reducing the percentage of holes, is reduced.

[0033] According to a further embodiment there is provided a sound absorbing assembly according to any of the preceding claims, characterised in that the sound absorbing assembly further comprises mounting a mounting frame arranged between the wall facing planar side of the support plate, and in that the support plate is mounted to the mounting frame by means of nails:

- of which the head size is lower than 150% of thickness of the yarns of the woven fabric top layer; and
- which project from the room facing planar side over a that is smaller than 80%, preferably smaller than 60%, of the woven top layer thickness.

[0034] In this way the sound absorbing assembly can be mounted to a support frame efficiently with the risk for damaging the woven fabric top layer and without leaving any visual traces as the head of the nail will visually disappear in between and/or below the yarns of woven fabric. Such nails can be for example mounted by means of a suitable air pressurized gun in order to allow for an efficient and consistent mounting of the nails. It is however clear that alternative mounting systems or combinations of mounting systems might be possible, preferably with minimal or without leaving visual traces of the mounting means or of any connection means in between neighbouring sound absorbing panels, such as for example one or more of the following:

- a tongue and groove mounting and/or connection;
- a click mounting and/or connection, preferably a tensioned click mounting and/or connection;
- mounting or connecting by means of gluing, such as for example gluing by means of a Poly-Urethane glue;
- etc.

[0035] According to a second aspect of the invention there is provided a method of manufacturing the sound absorbing assembly according to the first aspect of the invention, characterised in that the method comprises the sequential steps of:

- applying glue layer to the room facing planar side of the support plate, the glue layer thickness is in the range of 10% to 30% of the woven top layer thickness, by means of a glue application roller;
- placing the woven fabric top layer on top of the glue

layer on the room facing planar side of the support plate;

- temporary applying pressure by passing the support plate with the applied glue layer and the woven fabric top layer placed thereon, between pressure rollers, such that the layer thickness is reduced by a thickness in the range of 50% to 90%, preferably in the range of 75% to 85%, of the woven top layer thickness of the woven top layer.

[0036] In this way the improved sound absorbing assembly can be manufactured by means of a simple and efficient glue application process.

[0037] According to an embodiment there is provided for a method of manufacturing, characterised in that the glue layer preferably comprises a pressure-setting, Polyurethane glue.

[0038] In this way setting of the glue is further optimized, and is focussed to the specific parts of the yarns of the fabric that are pressed into the glue with a sufficiently large pressure in a simple and efficient way.

Brief Description of the Drawings

[0039]

Figure 1 schematically illustrates a cross section of an embodiment of a sound absorbing assembly according to the invention;

Figure 2 schematically illustrates a top view of an embodiment of a woven fabric forming a top layer of the embodiment of the sound absorbing assembly of Figure 1;

Figure 3 schematically illustrates a cross section of a fragment of the sound absorbing assembly of Figure 1 at an enlarged scale, comprising the embodiment of the woven fabric of Figure 2;

Figure 4 schematically illustrates an embodiment of the sound absorbing assembly similar to that of Figure 1 at a diminished scale, further showing an embodiment of mounting elements; and

Figures 5 and 6 respectively shows a table and graphic representation of sound absorption values of specific embodiments of the sound absorbing assembly.

Detailed Description of Embodiment(s)

[0040] Figure 1 schematically illustrates a cross section of an embodiment of a sound absorbing assembly 10. As shown the sound absorbing assembly comprises a support plate 30. As will be explained in further detail below, the support plate 30 is provided with a large number of support plate openings 33 and can thus gen-

erally be referred to as a perforated plate. A suitable material from which such a perforated support plate 30 can be manufactured is for example a medium-density fibre-board plate or MDF plate provided with a plurality of support plate openings 33. It is clear that other suitable materials for manufacturing such a perforated support plate are possible, such as for example a suitable gypsum plate provided with a plurality of support plate openings 33, which is preferable over an MDF or alternative wood based plate because of improved fire resistant properties. The support plate 30 according to this embodiment comprises a support plate thickness 32 of for example 8mm. It is clear that the support plate thickness 32 of the support plate 30 is the distance between its room facing planar side 35 and its opposing, wall facing planar side 37. It is clear that according to alternative embodiments alternative support plate thickness could be used as long as in general it is in the range of 5mm to 30mm, and preferably in the range of 6mm to 12mm. These ranges allow for a Helmholtz-resonator like effect as will be explained in more detail below.

[0041] The embodiment of the support panel of Figure 1, as shown comprises a plurality of support plate openings 33. As shown these support plate openings 33 extend through the support plate 30 from its room facing planar side 35 to its wall facing planar side 37. According to this embodiment the plurality of support plate openings comprising have cylindrical shape with a diameter 34 of 6mm. However it is clear that alternative shapes to the cylindrical shape are possible, such as for example suitable slots with a width of 6mm, conically drilled or milled shapes, etc. It is clear that still further alternative embodiments of the apertures etc. as long as in general the opening width 34 of these support plate openings 33, this means the diameter in case of a cylindrical opening or the width in the case of a longitudinal slot shaped opening, is in the range of 4mm to 12mm. As further shown, according to this embodiment, the centre-to-centre distance 36, this means the distance between the central longitudinal axes of two adjacent cylindrical support plate openings 33 is 8mm. It is clear that in this way a sufficient wall thickness for the structural walls 31 of the support plate 30 in between the support plate openings 33 is achieved. However it is clear that alternative embodiments are possible, as long as in general the centre-to-centre distance 36 is in the range of 110% to 500% of the opening width 34. According to the embodiment shown the plurality of support plate openings 33 can for example be provided by means of a triangular, square or other suitable drilling pattern for 6mm diameter holes through the support plate 30 with a centre-to-centre distance 36, sometimes also referred to as a hole-centre distance or an opening centre distance of 8mm. It is clear that, although only an enlarged part of the section of the sound absorbing panel 10 is shown, the length and width of this sound absorbing panel 10 is several orders of magnitude larger than the opening width 34 of its support plate openings 33 and thus a large number of for example

6mm diameter support plate openings 33 are provided in a sound absorbing panel 10 with a width and length of for example larger than 1 m.

[0042] It is clear that still further embodiments of the support plate 30 are possible, such as for example gypsum type support plates, for example of the type generally known as Gyptone or Rigitone, which for example comprise a gypsum plate with dimensions of length x width x thickness of about 1998 x 1188 x 12,5mm, comprises circular support plate openings 33 of for example respectively 6mm, 8mm or 10mm, and a centre-to-centre distance 36 of respectively 18mm, 18mm or 23 mm for respectively the types referred to as Rigitone 6/18, Rigitone 8/18 or Rigitone 10/23. These support plate openings 33 are arranged in a square drilling pattern, thereby respectively leading to an opening degree of 8,7%; 15,5% or 14,8% respectively. However it is clear that alternative embodiments comprising alternative dimensions are possible with respect to the length, width, thickness and the size of the openings of the plate. According to a particular alternative embodiment the length x width could for example be 3030mmx1280mm.

[0043] As shown a woven fabric top layer 20 is directly glued to the room facing planar side 35 of the support plate 30. As will be described in more detail below it is clear that this woven fabric top layer 20 consists of a woven fabric. As the woven fabric top layer 20 thus comprises only a woven fabric a simple and efficient construction and manufacturing of the sound absorbing assembly 10 can be realised. According to the embodiment shown the woven top layer thickness 22 of the woven top layer 20 is 1 mm. However it is clear that alternative embodiments are possible, as long as the woven top layer thickness 22 is in the range of 1/7 to 1/12 of the support plate thickness 32.

[0044] In this way the combination of the specific support plate openings 33 and the porosity of the woven top layer 20 as well as this specific ratio the thickness of the woven top layer in relation to the support plate will provide for an optimal Helmholtz-resonator like effect, while the undulating structure of the woven fabric of the woven fabric top layer 20, as well as the more or less round circumferential shape of the yarns of the woven fabric enhance dispersion, attenuation and absorption of sound pressure waves.

[0045] Figure 2 shows a top view of an embodiment of the woven fabric top layer 20 in more detail. As shown the woven fabric top layer 20 comprises a simple 1 by 1 basket weave weaving pattern of warp yarns 24 and weft yarns 26. As shown, in this way suitable openings 28 are created in between these respective yarns 24, 26 of the woven fabric top layer 20. According to this embodiment the yarns 24, 26 are yarns comprising a mono-filament glass fibre core and at least one polyvinyl chloride coating, for example a coextruded PVC coating could be chosen. Alternatives embodiments of the yarn are possible such as for example a mono-filament polyvinylchloride or polyester yarn, or other suitable filament polymer yarn.

According to still further alternatives the yarn could for example be filament glass fibre yarn. Although in general any suitable filament or spun yarn and/or synthetic or natural yarn could be used such the mono-filament yarn mentioned above are preferable as they also provide for good mechanical properties 10 when used as woven fabric top layer 20, such as an increased resistance to scratches, shocks, a good impact resistance, is moisture resistant, and allows for easy and efficient cleaning of the woven fabric top layer of the sound absorbing assembly when soiled. According to this embodiment the diameter 24D, as more clearly shown in Figure 3, of the yarn 24 is 0,5mm, which is approximately equal to 50% of the thickness 22 of the woven top layer 20. Alternative embodiments of the weaving pattern are possible such as for example a 2/2 basket weave, or any other suitable weaving pattern that can be defined for particular shed forming device of the weaving machine, that for example makes use of a suitable weaving frames or even more complicated patterns making use of for example a jacquard type shedding device.

[0046] Preferably the woven top layer 20 comprises a weaving pattern comprising a density in the range of 5 to 12, preferably 6 to 10, warp yarns 24 and or weft yarns 26 per centimetre. According to one embodiment referred to as "Chocolate" there are provided 8 warp yarns and 8 weft yarns per centimetre in a 2/2 basket weave pattern. According to an alternative embodiment referred to as "Sepia" there are provided 6 warp threads per centimetre and 10 weft threads per centimetre. As will be explained in further detail below this results in a suitable percentage of holes, this means the ration of the area of the holes 28 with respect to the area covered by the warp threads 24 and the weft threads 26, for the woven top layer 20, which according to specific tested embodiments of the sound absorbing assembly 10 lead to an Alpha-W value of 0,9. The specific yarns used in these embodiments referred to as "Chocolate" and "Sepia" are mono-filament yarns comprising a glass fibre core and a co-extruded polyvinyl chloride dual colour coating with a diameter of 0,5mm.

[0047] It is clear that alternative embodiments of such a woven top layer 20 are possible, for example comprising a percentage of holes in the range of 0,5% to 7%, preferably in the range of 1 % to 5%. As shown in more detail in Figure 3, the percentage of holes is determined largely by the ratio between the diameter 24D of the yarns 24, 26, the diameter or width 28D of the openings 28 in between the yarns 24, 26, the weaving pattern and the respective density of warp yarns and weft yarns. A suitable percentage of holes and a suitable level of undulation of the yarns 24, 26 of the woven top layer 20 can generally be achieved when the woven fabric top layer 20 comprises yarns 24, 26 with a thickness 24T in the range of 30% to 120% of the woven top layer thickness 22. According to the embodiment shown in Figure 1, the woven top layer thickness 22 is 1 mm and the thickness 24T of the yarns 24, 26, which according to this embod-

iment corresponds to the diameter 24D of the circular cross section of the yarns 24, 26, is 0,5 mm thereby corresponding to a ratio of 50%. It is clear, from for example Figure 3, that the thickness 24T of the yarn 24, 26 generally refers to the size of the cross-section of the yarn 24, 26 generally transverses to the plane of the woven fabric 20. When according to alternative embodiments the woven fabric 20 would comprise yarns 24, 26 with a non-circular cross section, such as for example a cross section resembling more a square, ellipsis, etc. the thickness 24T of the yarn 24, 26 of the woven fabric 20 will generally be determined by the maximum size of the cross section of the yarn along the direction generally transverses to the plane of the woven fabric 20.

[0048] As will be clear from Figure 3, preferably the thickness of the glue layer should be sufficiently large to allow for a secure connection between the undulating yarns of the woven top layer 20 and the room facing surface 35 of the support plate 30. According to the embodiment shown in Figure 1 there is applied a polyurethane glue of the type referred to as PUR 706.1 as produced by KebChemie M.G. Becker GmbH under the tradename KLEIBERIT. It comprises a Polyurethane basis, a density of $1,1\text{g/cm}^3$ and is of the pressure setting type, which cures when a sufficiently large amount of pressure is applied. According to this embodiment it is applied at a rate of 80g/m^2 . It is clear that alternative embodiments for the glue layer 100 are possible as long as preferably the woven fabric top layer 20 is directly glued to the room facing planar side 35 of the support plate 30 by means of this glue layer 100 of which the glue layer thickness 100D is in the range of 10% to 30% of the woven top layer thickness 22. As clearly shown in Figure 3, this allow the glue layer to cover a substantial part of the undulating yarns 24, 26 when they are nearest to the room facing planar side 35 of the support plate 30, while still leaving the diameter 28D of the openings 28 unchanged.

[0049] As further shown, according to the embodiment of Figure 1, the sound absorbing assembly 10 further also comprises a backing layer 40. The backing layer 40, as shown, comprises a backing layer thickness 42 being in the range of 0,1 mm to 5mm, preferably in the range of 0,2mm to 2mm. The backing layer 40 according to this embodiment comprises for example a non-woven tissue, preferably a non-woven tissue comprising glass fibres with a weight in the range of 50g/m^2 to 75g/m^2 and a fibre diameter in the range of $7\mu\text{m}$ to $15\mu\text{m}$. For example a glass fiber tissue mat referred to as MJ70B manufactured by Saint-Gobain Vetrotex of 70g/m^2 and comprising glass fibres with a diameter of $11\mu\text{m}$.

[0050] As further shown, according to the embodiment of Figure 1, the sound absorbing assembly 10 further comprises a wall cavity layer 50 in between the wall facing planar side 37 of the support plate 30 and the wall 60 when mounted. It is clear that, according to the embodiment shown in Figure 1, in which preferably, but optionally a backing layer 40 is mounted to the wall facing planar side 37 of the support plate 30, this means that the wall

cavity layer 50 is positioned in between this backing layer 40 and the wall 60 to which the support plate is mounted. It is also clear that wall is to be interpreted broadly, as any suitable surface to which the sound absorbing assembly could be mounted, such as for example any suitable surface of a room, for example its walls, ceiling, floor, etc. irrespective of the material of this wall, which could for example be a surface comprising stone, wood, glass, etc. The wall cavity layer thickness 52 being in the range of 15mm to 70mm, preferably in the range of 18mm to 55mm. According to one embodiment the wall cavity layer 50 has a thickness 52 of 50mm and is filled with mineral wool. According to a further embodiment wall cavity layer 50 has a thickness 52 of 20mm and is filled with a synthetic wool or a synthetic foam, which preferably has already been provided to the wall facing planar side 37 of the support plate 30 during manufacturing and before the mounting operation. Such a synthetic wool could for example comprise a suitable polymer wool, such as for example a polyester wool with a density in the range of 300g/m^2 to 750g/m^2 . A suitable synthetic foam could for example comprise a foam comprising melamine, polyethylene, poly-urethane, etc. It is clear that although preferably the wall cavity layer 50 is completely filled with such a mineral or synthetic wool or a synthetic foam, in general alternative embodiments are possible in which for example the wall cavity layer 50 is only partly filled with such materials.

[0051] As shown in more detail in Figure 4, according to the embodiment of Figure 1, the sound absorbing assembly 10 further also comprises a mounting frame 70, arranged between the wall facing planar side 37 of the support plate 30 and the wall 60 when mounted. The support plate 30, as shown, is mounted to the mounting frame by means of suitable nails 72. Preferably these nails 72 have a head size that lower than 150% of thickness 24D of the yarns 24, 26 of the woven fabric top layer 20. Preferably the nails 72 are inserted, for example by means of hammering or a suitable air-gun, such that the nails 72 project from the room facing planar side 35 over a distance that is smaller than 80%, preferably smaller than 60%, of the woven top layer thickness 22. According to this embodiment with a woven top layer thickness 22 of 1 mm about 0,3 mm. In this way the nails 72 are no longer visible. Preferably the nails 72 penetrate the fabric top layer 20 and preferably even penetrate beyond the room facing planar side 35 into the support plate 30 with their head, as this still further reduces the risk for visibility of the nails. In this way the sound absorbing assembly 10 can be mounted to the mounting frame 70 from its room facing side without causing damage or leaving visual traces of the mounting means.

[0052] Figures 5 and 6 respectively shows a table and graphic representation of sound absorption values of specific embodiments of the sound absorbing assembly 10 very similar to the embodiment described with reference to Figure 1, which preferably have the support plate thickness 32 in the range of 6mm to 12mm; and a woven

top layer thickness 22 of the woven top layer 20 is in the range of 1/8 to 1/10 of the support plate thickness 32.

[0053] The left column A, labelled 200, of Sound Absorption Coefficients or Alpha-s in Figure 5 and the corresponding chart with diamond shaped reference points in Figure 6, relates to an embodiment with a woven top layer thickness 22 of 1 mm of the "Sepia" embodiment of the fabric referenced above, combined with a support plate thickness 32 of 8mm and a drilling pattern for the support plate openings with a diameter 34 for the openings 33 of 6mm and a centre-to-centre distance 36 of 8mm, comprising the MJ70B backing layer 40 referenced above and a wall cavity layer 50 with a thickness of 50mm filled with mineral wool. As shown this embodiment results in a Weighted Sound Absorption Coefficient in accordance with the ISO 11654 standard, also referred to as Alpha-W of 0,9.

[0054] A second embodiment is shown in the second column B, labelled 201, of Sound Absorption Coefficients or Alpha-s in Figure 5 and the corresponding chart with square shaped reference points in Figure 6. This embodiment is identical to the one related to column A, except that now an embodiment with a woven top layer thickness 22 of 1 mm of the "Chocolate" embodiment of the fabric referenced above is used. As shown this embodiment results in a Weighted Sound Absorption Coefficient in accordance with the ISO 11654 standard, also referred to as Alpha-W of 0,9.

[0055] A third comparative embodiment is shown in the third column C labelled 202 of Sound Absorption Coefficients or Alpha-s in Figure 5 and the corresponding chart with triangular shaped reference points in Figure 6. This embodiment is identical to the one related to column B, except that now instead of the non-woven MJ70B backing layer 40 a woven fabric is used as backing layer and the support plate has a support plate thickness 32 of 16mm. As shown, this embodiment results in a Weighted Sound Absorption Coefficient in accordance with the ISO 11654 standard, also referred to as Alpha-W of 0,85. This corresponds to a ratio of the woven top layer thickness 22 of the woven top layer 20 of 1mm that is 1/16 of the support plate thickness 32 of 16mm. Generally, when using an increased support plate thickness a higher sound absorption coefficient is to be expected, however, as shown, according to this embodiment of which the ratio of top layer thickness 22 with respect to support plate thickness 32 is outside the optimal range of 1/7 to 1/12, the measured Alpha-W of 0,85 is surprisingly lower than the Alpha-W of 0,9 of the first and second embodiment described above which have a support plate thickness 32 of only 8mm, but do have a ratio with the optimal range of 1/7 to 1/12.

[0056] A fourth embodiment is shown in the fourth column D, labelled 203, of Sound Absorption Coefficients or Alpha-s in Figure 5 and the corresponding chart with cross shaped reference points in Figure 6. This embodiment is identical to the one related to column A, except that now an embodiment with a wall cavity layer 50 with

a thickness of 20mm filled with polyester wool with a density in the range of 300g/m² to 750g/m² is used. As shown this embodiment results in a Weighted Sound Absorption Coefficient in accordance with the ISO 11654 standard, also referred to as Alpha-W of 0,6. This is still a high Alpha-W value considering the limited thickness of the entire sound absorbing assembly being reduced to about 30mm, thereby reducing consumption of the volume at the circumferential walls of the room which is to be provided with such sound absorbing assemblies.

[0057] A fifth comparative embodiment is shown in the fifth column E of Sound Absorption Coefficients or Alpha-s in Figure 5 and the corresponding chart with dot shaped reference points in Figure 6 and labelled 204. This embodiment is identical to the one related to column A, except that now an embodiment with a woven top layer thickness 22 of 0,57mm of an embodiment of the fabric sold under the trade name Alkenz Soley Fabrics Sunshadow 3000 N 1%. This woven top layer comprises a woven fabric comprising:

- Mono-filament polymer Yarns comprising a combination of 25% polyester en 75% polyvinyl chloride;
- A weaving pattern comprising a 2/2 basket weave with 7 warp yarns per centimeter and 5 weft yarns per centimeter;
- A weight of 520g/m²

As shown this embodiment results in a Weighted Sound Absorption Coefficient in accordance with the ISO 11654 standard, also referred to as Alpha-W of 0,3. It is thus clear that such a comparative embodiment with a ratio of the woven top layer thickness 22 to the support layer thickness 32 of 0,57mm / 8mm, which approximates 1/14 and falls out of the optimal range of 1/7 to 1/12, forms a good reference for the first and second embodiment that comprise a ratio that falls within this optimal range, as these embodiments all have the same support plate thickness of 8mm. A ratio inside of this optimal range of 1/7 to 1/12 surprisingly results in a clear and high rise of the sound absorption coefficient of the sound absorbing assembly.

[0058] The sound absorbing assembly 10 can be manufactured by means of a simple and robust manufacturing process in which the woven fabric top layer 20 is glued to the room facing planar side 35 by means of an efficient roller coater. First the glue layer 100 is applied by means of a glue application roller of the roller coater to the room facing planar side 35 of the support plate 30. According to this embodiment the glue layer thickness 100D is about 0,2mm when glue is applied at 80g/m² for a woven top layer thickness 22 of 1 mm. However alternative embodiments are possible, as long as the glue layer thickness 100D is in the range of 10% to 30% of the woven top layer thickness 22. Subsequently the woven fabric top layer 20 is placed on top of the glue layer 100 on the room facing planar side 35 of the support plate 30. Then pressure rollers of the roller coater will temporary apply-

ing pressure by passing the support plate 30 with the applied glue layer 100 and the woven fabric top layer 20 placed thereon, between pressure rollers. These pressure rollers will be positioned, such that the layer thickness is reduced by a thickness in the range of 50% to 90%, preferably in the range of 75% to 85%, of the woven top layer thickness 22 of the woven top layer 20. According to the embodiment of Figure 1 for a woven top layer thickness 22 of 1 mm, a glue layer thickness 100D of 0,2mm and a support plate thickness 32 of 8m, the thickness is reduced by 8mm, or 80% of the woven top layer thickness 22.

[0059] It is further clear that, because of the relatively large dimensions of the support plate openings 33, the glue layer 100 will only be applied to the room facing plane 35 of the structural walls 31 of the support plate 30 by the glue application roller. As already explained above preferably the glue layer 100 comprises a pressure-setting, Polyurethane glue.

[0060] It is clear that still further embodiments for the sound absorbing assembly 10 are possible, more particularly instead of a fabric top layer 20 consisting of a woven fabric, there could be made use of a knitted fabric 20 as long as in general the top layer thickness 22 of the knitted fabric top layer 20 is in the range of 1/7 to 1/12 of the support plate thickness 32. Thus in general with reference to the embodiments and optimizations described above, where applicable when referring to a woven fabric top layer, a woven top layer, a woven top layer thickness, etc., in general similar embodiments and optimizations could be provided for with a knitted fabric 20 with similar openings 28 in between similar yarns. Thus in general the above described embodiments can alternatively also be described with a knitted top layer and a knitted top layer thickness. Thereby in general the term fabric top layer and fabric top layer thickness is to be interpreted as covering both alternatives of a woven fabric or a knitted fabric. However it is clear that a woven fabric is preferable as it provides for improved structural stability and resistance to wear.

[0061] It is further clear that, when referring to the fabric top layer of the sound absorbing assembly, this means that, when mounted, this fabric top layer forms the room facing planar side of the sound absorbing assembly. It is thus clear that no further layers or planar elements are provided covering this fabric top layer of the sound absorbing assembly at the room facing side when mounted.

[0062] Woven fabric in the context of this application refers to a textile formed by weaving that is produced on a loom by interweaving warp and weft threads.

[0063] When referring to mono-filament yarn in the context of this application, there is referred to a yarn comprising preferably a thick, single continuous and/or relatively long filament as opposed to spun yarns.

[0064] Mineral wool in the context of this application, is also known as mineral fibre, mineral fibre, stone wool, man-made mineral fibre or MMMF, and man-made vitreous fibre or MMVF, is a name for fibre materials that

are formed by spinning or drawing molten minerals or synthetic minerals such as slag and ceramics.

[0065] When referring to a room facing surface 35 of the support plate 20, this means the surface 35 directed towards the most likely location of sound generating sources in the room when the sound absorbing assembly is mounted to a wall, ceiling or other suitable circumferential part of a room.

[0066] When referring to Sound Absorption Coefficients or Alpha-s in the context of this description, this refers to Sound Absorption Coefficients or Alpha-s value determined during measurements in accordance with standards EN ISO 354:2003 and/or EN ISO 11654:1997. These measurements were performed at a reverberation room with a volume $V=296,9\text{m}^3$ and a total surface area $S_{\text{tot}}=278,2\text{m}^2$. At a temperature of $T=10,4$ at empty space and $T=10,6$ with test element present. At an atmospheric pressure of $p=100,7\text{kPa}$ and at a relative humidity $hr=68,6\%$. The area of the test element being $10,82\text{m}^2$.

[0067] When referring to a Weighted Sound Absorption Coefficient in the context of this description, this refers to a Weighted Sound Absorption Coefficient in accordance with the ISO 11654 standard, also referred to as Alpha-W. The ISO 11654 standard describes how frequency dependent Sound Absorption Coefficients of octave bands of 250Hz to 4kHz are converted to a single number which is the Alpha-W value.

[0068] Although the present invention has been illustrated by reference to specific embodiments, it will be apparent to those skilled in the art that the invention is not limited to the details of the foregoing illustrative embodiments, and that the present invention may be embodied with various changes and modifications without departing from the scope thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein. In other words, it is contemplated to cover any and all modifications, variations or equivalents that fall within the scope of the basic underlying principles and whose essential attributes are claimed in this patent application. It will furthermore be understood by the reader of this patent application that the words "comprising" or "comprise" do not exclude other elements or steps, that the words "a" or "an" do not exclude a plurality, and that a single element, such as a computer system, a processor, or another integrated unit may fulfil the functions of several means recited in the claims. Any reference signs in the claims shall not be construed as limiting the respective claims concerned. The terms "first", "second", "third", "a", "b", "c", and the like, when used in the description or in the claims are introduced to distinguish between similar elements or steps and are not necessarily describing a sequential or chronological order. Similarly,

the terms "top", "bottom", "over", "under", and the like are introduced for descriptive purposes and not necessarily to denote relative positions. It is to be understood that the terms so used are interchangeable under appropriate circumstances and embodiments of the invention are capable of operating according to the present invention in other sequences, or in orientations different from the one(s) described or illustrated above.

Claims

1. A sound absorbing assembly (10), comprising:

- a support plate (30) comprising:

- a support plate thickness (32), between its room facing planar side (35) and its opposing, wall facing planar side (37), in the range of 5mm to 30mm;

- a plurality of support plate openings (33) extending through the support plate (20) from its room facing planar side (35) to its wall facing planar side (37), comprising an opening width (34) in the range of 4mm to 12mm, and a centre-to-centre distance (36) in the range of 110% to 500% of the opening width (34); and

- a fabric top layer (20) which is directly glued to the room facing planar side (35) of the support plate (30) and which consists of a woven or knitted fabric;

CHARACTERIZED IN THAT

the top layer thickness (22) of the fabric top layer (20) is in the range of 1/7 to 1/12 of the support plate thickness (32).

2. A sound absorbing assembly (10) according to claim 1, **characterised in that**:

- the support plate thickness (32) is in the range of 6mm to 12mm; and

- the top layer thickness (22) of the fabric top layer (20) is in the range of 1/8 to 1/10 of the support plate thickness (32).

3. A sound absorbing assembly (10) according to claim 1 or 2, **characterised in that** the fabric top layer (20) comprises yarns (24, 26) with a thickness in the range of 80% to 120% of the top layer thickness (22).

4. A sound absorbing assembly (10) according to any of the preceding claims, **characterised in that** the yarns (24, 26) comprise a mono-filament yarn.

5. A sound absorbing assembly (10) according to any of the preceding claims, **characterised in that** the

yarns (24, 26), comprise one or more of the following:

- a yarn comprising a mono-filament glass fibre core and at least one polymer coating;
- a filament yarn, preferably a mono-filament yarn comprising at least one polymer;
- a mono-filament glass fibre yarn.

6. A sound absorbing assembly (10) according to any of the preceding claims, **characterised in that** the fabric top layer (20) comprises a percentage of holes in the range of 0,5% to 7%, preferably in the range of 1% to 5%.

7. A sound absorbing assembly (10) according to any of the preceding claims, **characterised in that** the fabric top layer (20) consists of a woven fabric, and this woven fabric top layer (20) comprises a weaving pattern comprising a density in the range of 5 to 12, preferably 6 to 10, warp yarns (24) and or weft yarns (26) per centimetre.

8. A sound absorbing assembly (10) according to any of the preceding claims, **characterised in that** the sound absorbing assembly (10) further comprises a wall cavity layer (50) in between the wall facing planar side (37) of the support plate (30) and the wall (60), when mounted, the wall cavity layer thickness (52) being in the range of 15mm to 70mm, preferably in the range of 18mm to 55mm.

9. A sound absorbing assembly (10) according to claim 8, **characterised in that** the wall cavity layer (50) comprises one or more of the following:

- a mineral wool;
 - a synthetic wool;
 - a synthetic foam,
- and **in that** the support plate (30) comprises one or more of the following:

- a medium-density fibreboard plate;
- a gypsum plate.

10. A sound absorbing assembly (10) according to claim 8 or 9, **characterised in that** the sound absorbing assembly (10) further comprises a backing layer (40), the backing layer thickness (42) being in the range of 0,1mm to 5mm, preferably in the range of 0,2mm to 2mm.

11. A sound absorbing assembly (10) according to claim 10, **characterised in that** the backing layer (40) comprises a non-woven tissue, preferably a non-woven tissue comprising glass fibres with a weight in the range of 50g/m² to 75g/m² and a fibre diameter in the range of 7µm to 15µm.

12. A sound absorbing assembly (10) according to any of the preceding claims, **characterised in that** the fabric top layer (20) which is directly glued to the room facing planar side (35) of the support plate (30) by means of a glue layer (100) of which the glue layer thickness (100D) is in the range of 10% to 30% of the fabric top layer thickness (22). 5
13. A sound absorbing assembly (10) according to any of the preceding claims, **characterised in that** the sound absorbing assembly (10) further comprises mounting a mounting frame (70) arranged between the wall facing planar side (37) of the support plate (30) and the wall (60) when mounted, and **in that** the support plate (30) is mounted to the mounting frame by means of nails (72): 10
- of which the head size is lower than 150% of thickness (24T) of the yarns (24, 26) of the fabric top layer (20); and 20
 - which project from the room facing planar side (35) over a that is smaller than 80%, preferably smaller than 60%, of the fabric top layer thickness (22). 25
14. A method of manufacturing the sound absorbing assembly according to any of the preceding claims, **characterised in that** the method comprises the sequential steps of: 30
- applying glue layer (100) to the room facing planar side (35) of the support plate (30), the glue layer thickness (100D) is in the range of 10% to 30% of the fabric top layer thickness (22), by means of a glue application roller; 35
 - placing the fabric top layer (20) on top of the glue layer (100) on the room facing planar side (35) of the support plate (30); and
 - temporary applying pressure by passing the support plate (30) with the applied glue layer (100) and the fabric top layer (20) placed thereon, between pressure rollers, such that the layer thickness of this assembly is reduced by a thickness in the range of 50% to 90%, preferably in the range of 75% to 85%, of the fabric top layer thickness (22) of the woven top layer (20). 40 45
15. A method of manufacturing according to claim 14, **characterised in that** the glue layer (100) comprises a pressure-setting, Polyurethane glue. 50

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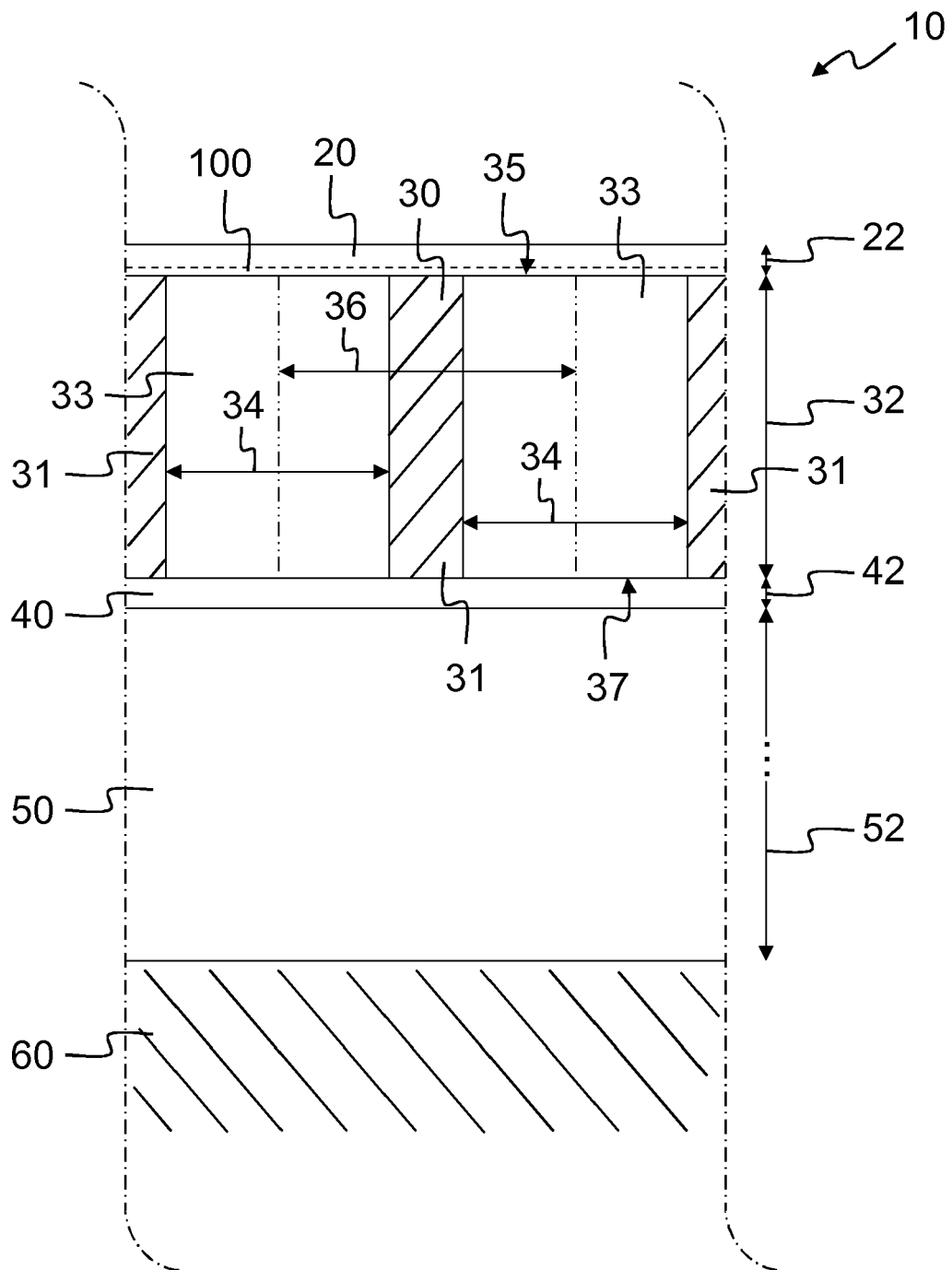


Fig. 1

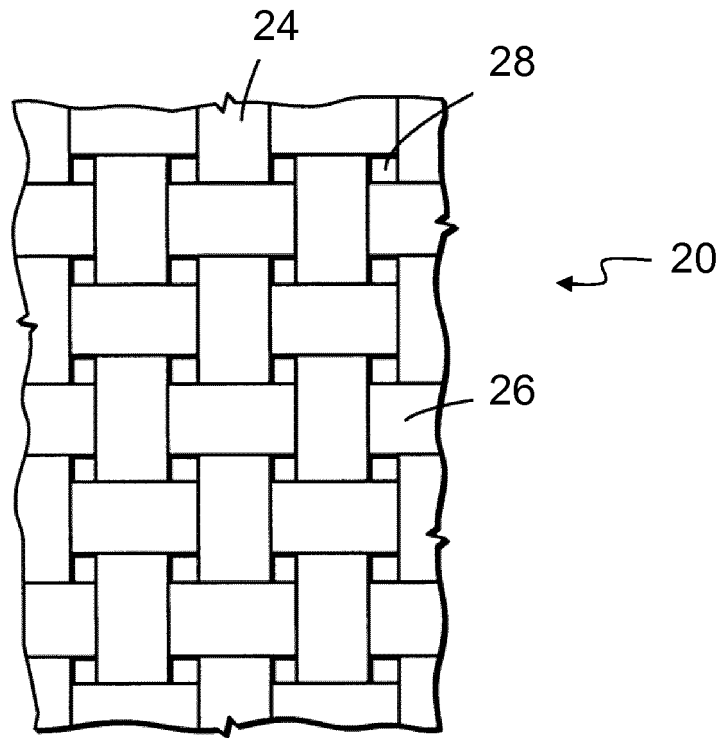


Fig. 2

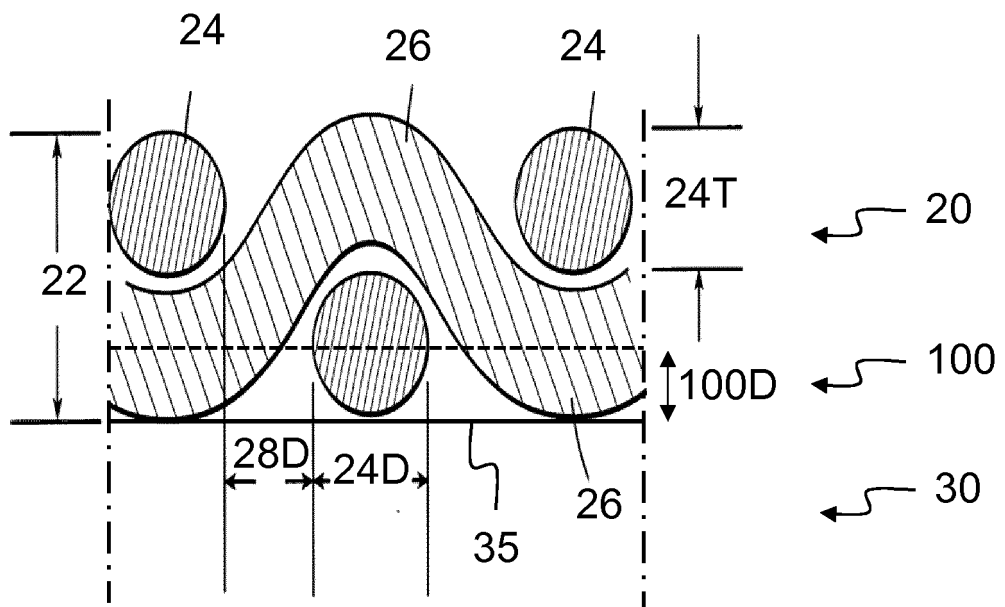


Fig. 3

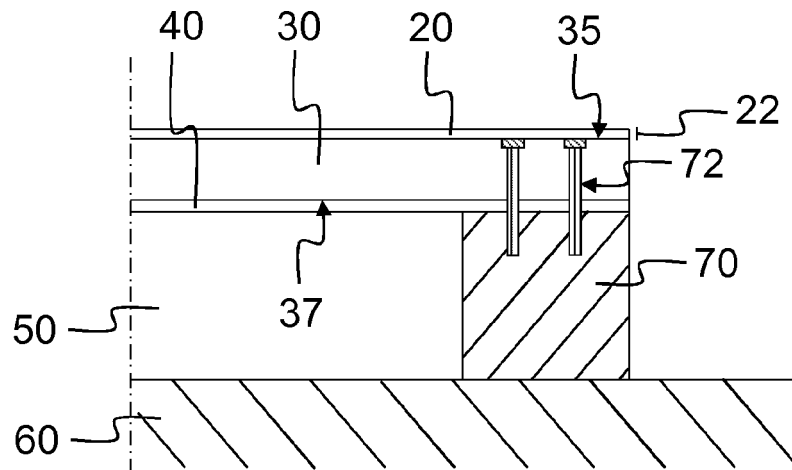


Fig. 4

	200	201	202	203	204
	A	B	C	D	E
f(Hz)	Alpha-s	Alpha-s	Alpha-s	Alpha-s	Alpha-s
100	0.13	0.21	0.12	0.06	0.44
125	0.26	0.28	0.24	0.09	0.64
160	0.32	0.37	0.35	0.13	0.52
200	0.52	0.56	0.52	0.24	0.51
250	0.67	0.76	0.71	0.32	0.41
315	0.85	0.94	0.89	0.41	0.35
400	0.98	0.97	1.01	0.51	0.29
500	0.96	0.98	0.96	0.62	0.28
630	0.94	1.00	0.91	0.72	0.27
800	0.90	0.92	0.83	0.79	0.26
1000	0.89	0.88	0.78	0.86	0.26
1250	0.85	0.85	0.75	0.91	0.26
1600	0.83	0.83	0.75	0.92	0.25
2000	0.85	0.85	0.78	0.91	0.25
2500	0.90	0.88	0.81	0.90	0.25
3150	0.89	0.85	0.83	0.87	0.26
4000	0.91	0.82	0.87	0.85	0.27
5000	0.99	0.87	1.01	0.87	0.30
Alpha-W	0.90	0.90	0.85	0.60	0.30

Fig. 5

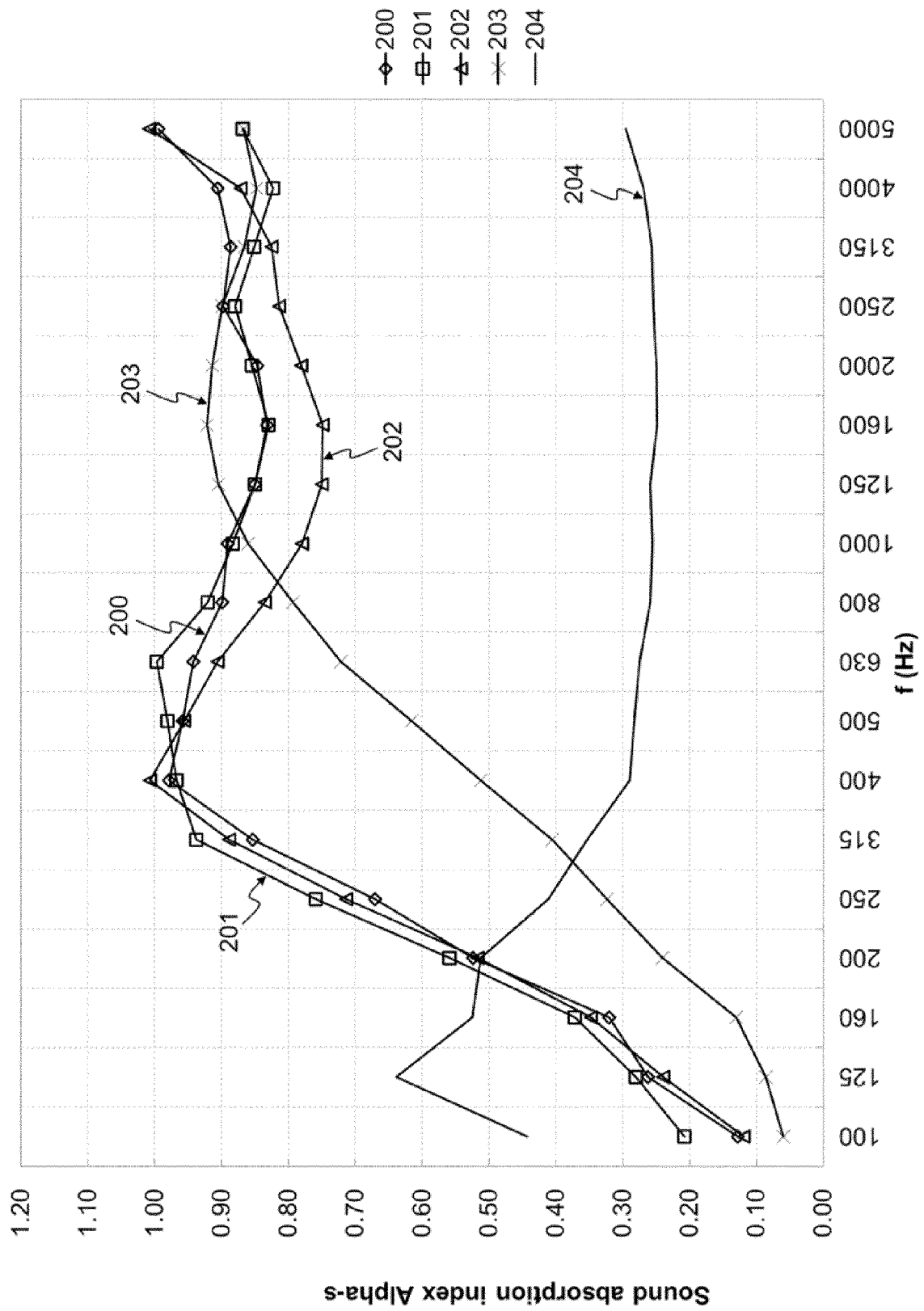


Fig. 6



EUROPEAN SEARCH REPORT

Application Number
EP 15 16 0097

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	GB 754 252 A (FIBROUS PLASTER CEILINGS PROPR) 8 August 1956 (1956-08-08) * the whole document *	1-15	INV. E04B1/84
X,D	DE 198 39 973 A1 (FRAUNHOFER GES FORSCHUNG [DE]) 23 March 2000 (2000-03-23) * the whole document *	1-15	
X	DE 20 2007 004823 U1 (GEIPEL UDO [DE]) 2 August 2007 (2007-08-02) * paragraph [0019] - paragraph [0020]; figure 1 *	1-15	
			TECHNICAL FIELDS SEARCHED (IPC)
			E04B
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 22 September 2015	Examiner Galanti, Flavio
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 15 16 0097

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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22-09-2015

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