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(54) **Self-supporting, generally flat construction element**

(57) A sound-absorbing generally flat construction element is disclosed having a substantially laminated structure comprised of a support layer disposed between two covering layers at least one of which is permeable to air. The support layer has an open-cell structure, the cells of which extend between and open to the covering layers, and has a compressive strength in the direction normal to the faces of the element which is greater than that of each covering layer and a tensile strength in the direction parallel to the faces of the element which is smaller than that of each covering layer. The support layer is compacted at least in the region of the border or marginal areas of the construction element.

The support layer can be of honeycomb structure or formed from corrugated material and the covering layers can take various forms reference being made to resin-bonded non-woven fibrous material and air-permeable PVC foil which may be laminated with a foamed material.

The construction element is of application, for example, as a roof soffit or as a lining for automobiles and possesses sound-absorbing properties combined with rigidity and lightweight.

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Fig. 1a

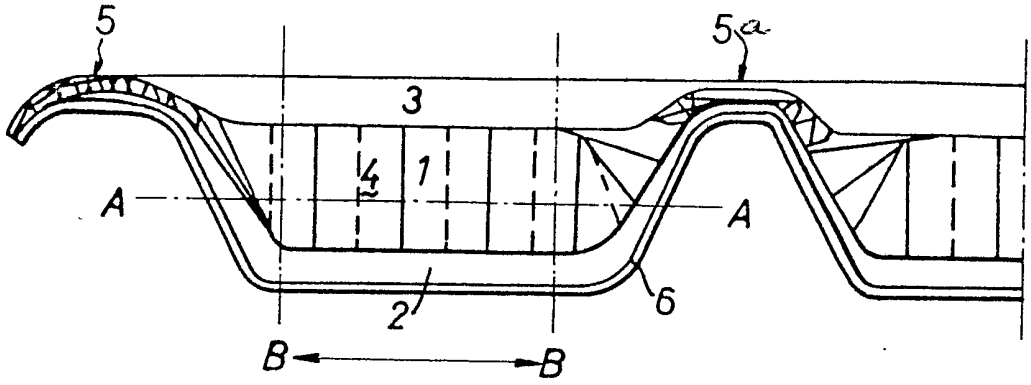


Fig. 1b

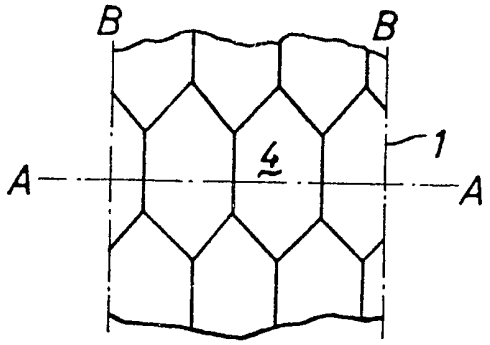


Fig. 2a

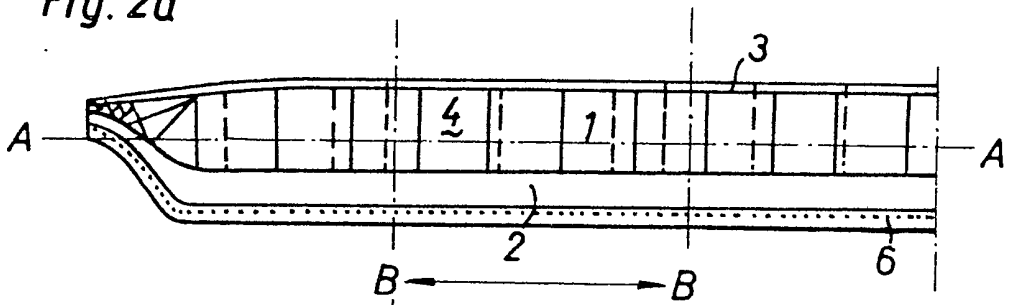
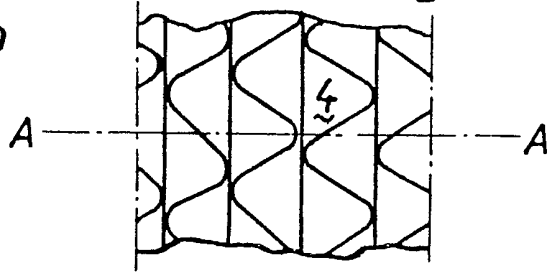


Fig. 2b



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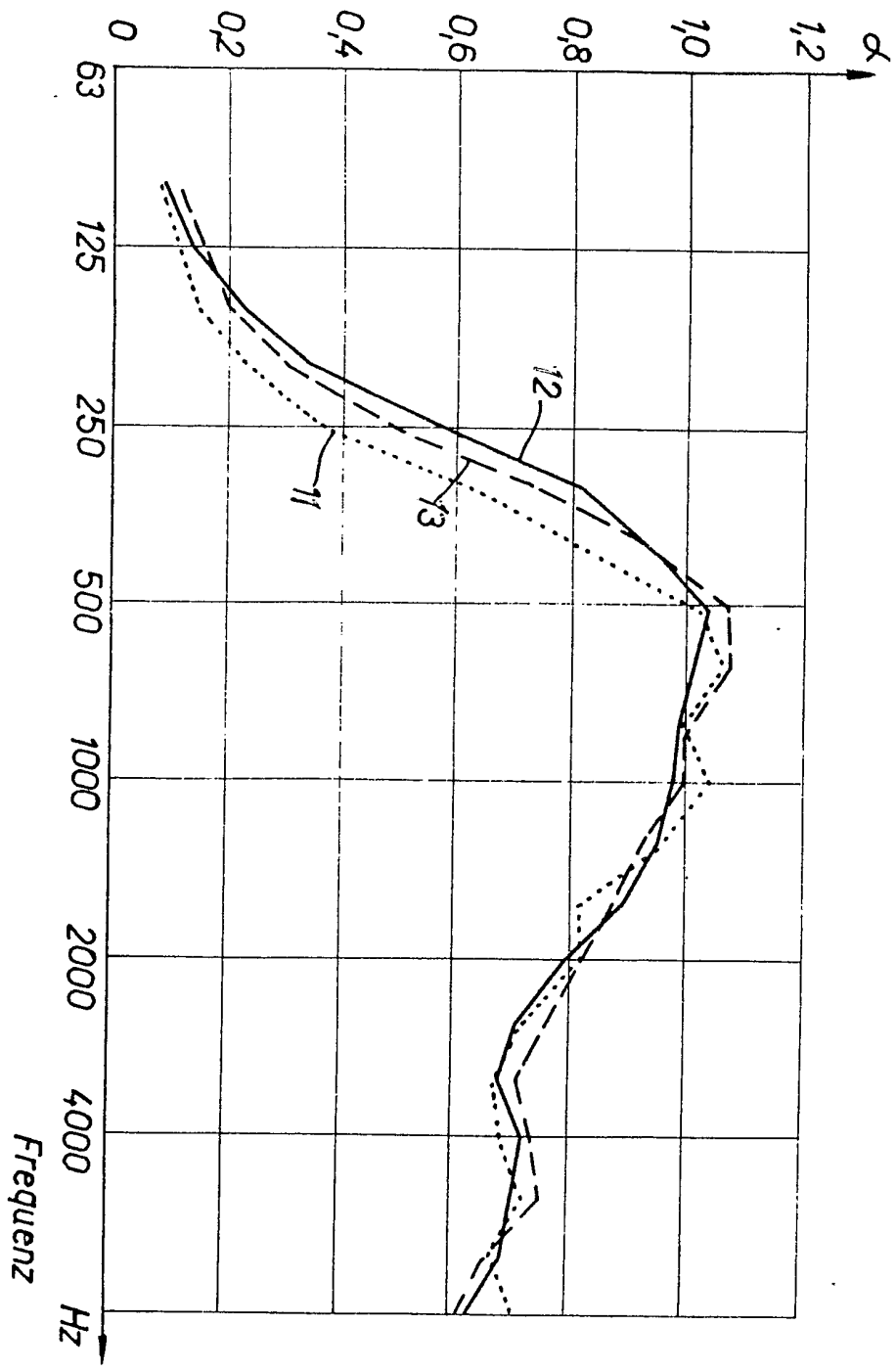

Fig. 3

SPECIFICATION

Self-supporting, generally flat construction element

The present invention relates to a self-supporting, generally flat or planar construction element or panel comprising a support layer, with a covering layer on each of the two opposed faces thereof. Light and stiff panels of composite material are known and are commercially available, consisting of a honeycombed or undulating lightweight layer connected between two foils of materials, such as kraft paper, chipboard, wood cement panels, aluminium sheet or steel sheet, etc. Such elements are used, for example, as palette floors, door fillings, lightweight wall elements (prefabricated construction), packaging material.

All known forms of construction suffer from the disadvantage that on the one hand they are not deformable and therefore cannot be adapted to a pre-shaped substrate (portion of bodywork) and on the other hand to not possess any acoustic effectiveness and thus are not suitable as noise-counteracting means.

On the other hand, generally flat, stiff components, such as roof soffits of automobiles possessing acoustic effectiveness are known, which consist of pressed and resin bonded felts. These components are relatively heavy since for obtaining sufficient stiffening either materials having a high weight per unit area or stiffening elements must be used.

Furthermore, more recently, stiff, generally flat moulded components have been developed which consist of closed-cell rigid foams having impermeable covering foils. Such components, such as automobile roof soffits, are indeed light, but on account of their high compressive sensitivity or brittleness and lack of flexibility, are very difficult to handle and are therefore not very suitable for rational assembly. In particular, however, they are acoustically ineffective.

The task underlying the present invention therefore is to create a deformable, acoustically effective construction element, which possesses adequate stiffness to be self-supporting, and has a relatively low volumetric weight. In addition, it should possess favourable properties in respect of rational assembly as an acoustically effective element in modern automobile construction.

According to the present invention there is provided a self-supporting, generally substantially flat construction element or panel comprising a support layer, on each of the two outer faces of which a covering layer is disposed characterised in that at least one covering layer is permeable to air, that the support layer has an open-cell structure with cells extending substantially transversely to the faces and the compressive strength of the support layer in the direction transverse to the faces is greater than that of each of the covering layers, whereas the tensile strength of the support layer in the general direction parallel to the faces is smaller than that of each of the covering layers, and in that the support layer is deformed in relief-like manner by compaction or compression at least in the region of the border of the construction element.

The new construction element possesses, as a consequence of the combination of an air-permeable covering layer with a cell structure open towards that covering layer, good acoustic absorption properties from this air permeable side. Although the support structure is partly compacted or compressed corresponding to the shaping and contour required, the open-cell structure and the stiffness of the element are maintained at these points also.

Embodiments of the present invention will now be described by way of example, reference being made to the accompanying drawings, in which:-

Figure 1a is a somewhat diagrammatical fragmentary vertical section of a roof soffit or lining for autombiles according to the invention,

Figure 1b is a section taken on the line A-A of Figure 1*a* between the lines B-B,

Figure 2a is a view similar to Figure 1*a* showing an alternative embodiment of the invention,

Figure 2b is a section taken on the line A-A of Figure 2*a* between the lines B-B, and

Figure 3 is a graph showing the results of echo chamber measurements for different materials.

Referring to the embodiment illustrated in Figures 1*a* and 1*b*, a roof soffit or lining for automobiles comprises a support layer 1 bonded between opposed layers 2 and 3. The support layer 1 is of honeycomb construction and may be, for example, a commercially available glued cardboard structure which, when pulled apart, opens to form the honeycombs, the passages 4 of which extend between the layers 2 and 3 and open to both layers. The layer 2 is air-permeable and in this example, is formed from resin bonded non-woven fibrous material such as a random orientated fibre fleece or needle felt. The layer 3 in this example, is similarly formed from resin bonded non-woven fibrous material such as a random orientated fibre fleece or needle felt. The air permeable layer 2 is covered with an air permeable decorative layer 6 which is bonded thereto in an air permeable manner by an adhesive and which may be a simple textile decorative layer which is disposed on the side presented to the interior the vehicle.

The composite generally planar panel or laminate is compressed about its periphery or marginal edge as at 5 for attachment to the automobile bodywork or panels and may be formed with apertures where it is compressed, e.g., by punching holes therethrough to facilitate such attachment. The composite panel may be additionally compressed in other regions such as 5*a*, for example, to allow a roof light to be fitted in the automobile. The compressed areas of the composite panel still retain an open-cell structure and the required degree of stiffness.

The support layer 1 can be made of other materials, e.g., kraft paper or a plastics material and can be of a

different configuration such as a corrugated paper or cardboard structure as is described with reference to Figures 2*a* and 2*b*. In this embodiment, the composite panel is intended as a roof soffit or lining for an automobile and is shaped to conform with the contour of the roof panel to which it is bonded during assembly.

The support layer 1 comprises a plurality of corrugated cardboard layers or sheets which are bonded together and which may additionally be impregnated with a flame-retarding agent or with a synthetic resin. The passages 4 formed by the corrugations extend between and open to the layers 2 and 3. The air-permeable layer 2, as in the previous example, is formed from a resin bonded random orientated fibre fleece or needle felt and, although the layer 3 could be similarly constructed, it is in this case formed from a thin, tear resistant kraft paper or a thin layer of plastics material or of cardboard. The air permeable decorative layer 6 presented to the interior of the vehicle is formed from perforated PVC foil laminated with open-cell polyurethane foam, the foam being on the face presented to the layer 2. The foam may be omitted if desired.

When glued or otherwise secured to the interior of an automobile roof, the composite panel of the invention not only absorbs acoustic energy from the passenger space but also damps noise producing oscillations of the roof panel.

It will be appreciated that in the above described embodiments, the support layer 1 has a compressive strength or resistance to compression in the general direction normal to the opposed faces of the composite panel, i.e., in the direction of the passages 4, which is greater than that of the covering layers 2 and 3 and that the tensile strength of the support layer 1 in a direction parallel to the opposed faces or normal to the direction of the passages 4 is less than that of each of the covering layers 2 and 3.

As can be seen in Figures 1*a* and 2*a* of the accompanying drawings, the compression or compaction of the composite panel in the areas 5 and 5*a* is such that in these areas the total thickness of the compacted panel is less than the original thickness of the support layer 1.

In a further embodiment of a construction element according to the invention, the element is constructed with one covering layer 2 of a fibre-reinforced plastics or of another material of high tensile strength and the other covering layer 3 shaped to the contour of the bodywork plating, to which it is to be attached, from a compressed, resin-bonded random orientated fibre fleece or needle felt. This construction element, which is firmly bonded to the automobile body plating, produces strong damping of resonance vibrations of the thus equipped plating. Thus, the effect of highly disturbing, low-frequency noises sources of automobiles, and also of stationary machines and equipment can be materially reduced.

In another embodiment of the invention, the construction element is constructed as in the foregoing example, but with the difference that the one covering layer 2 is of a heavy air permeable foil instead of fibre-reinforced plastics material. Such an element, if it is mounted with the heavy layer outwards on a sound-emitting surface, produces very good acoustic damping or insulation. In this way acoustic transmission through the air from a disturbing noise source, for example the engine of an automobile, can be largely suppressed in the passenger space. For producing a roof lining for automobiles according to the embodiment illustrated diagrammatically in Figures 1*a* and 1*b*, a random orientated fibre fleece mat 2 of, for example, cotton fibres of 300 g/m^2 and bonded for example with phenolic resin of the Novolake type by partial cross-linking, a generally flat, approx. 1 cm deep honeycomb structure 1 impregnated with synthetic resin to strengthen it such as is commercially obtainable as a glued kraft paper structure which can be pulled out to a honeycomb structure and above these again a pre-hardened, random orientated fibre fleece mat 3 of 300 g/m^2, are introduced into a heated pressing mould and pressed and hardened for 2½ minutes at 180°C. The pressing is here carried out essentially only down to a total thickness of approx. 1.2 cm. The thus obtained moulding is then stamped out to the correct contour with compacted marginal areas and subsequently glued to a textile decorative layer 6. In this way a self-supporting acoustically insulating roof lining is obtained for a medium-class vehicle having an extraordinarily low weight per unit area of only 1.1 kg/m^2. Conventional acoustically active self-supporting roof linings, by contrast, weigh from 2-3 kg/m^2.

The sound-absorption effect of the thus obtained roof lining is excellent and is approximately equal in the medium frequency range (500-1500 Hz) to that of a resin-bonded random orientated fibre mat for absorption purposes of the same thickness and weight, whereas in the region of higher (1500-2000 Hz) and lower frequencies (100-500 Hz) it is even slightly superior. By contrast, such a fibre mat is about 1000 times less stiff, expressed as modulus of elasticity.

In a further example, the production of an element according to this invention for noise reduction in the engine space of a private vehicle will be described.

For this purpose, a phenolic resin-bonded cotton random orientated fibre fleece mat 2 of 300 g/m^2, a support layer 1 having a honeycomb structure of approx. 600 g/m^2 and approx. 2.5 cm thick, a multilayered mat 3 comprising a further fibre mat as above and a layer of a needle felt of polyester fibres of approx. 200 g/m^2 are placed in a heated press and shaped and hardened for approximately 3 minutes at 180°C to a maximum thickness of approx. 4 cm. After pressing to shape, the obtained engine space absorption element identified as 11 is tested for bending strength and sound absorption capacity. For comparison, two engine space absorption elements 12 and 13, of the same size and form but of different construction, were made. One of these, 12, consisted of two phenolic resin-bonded random orientated fibre fleeces, as used above, but each of 1500 g/m^2 weight and of the same needled polyester fibre fleece of 200 g/m^2. The other, 13, was constructed in analogous manner to the construction element of this invention, except that the support layer

1 was substituted by a layer of open-cell polyurethane soft foam of 15 kg/m^3 and approx. 3 cm thickness, whereby however a maximum thickness of approx. 5 cm instead of 4 cm and an unsatifactory contour trueness in regard to the element thickness resulted.

Figure 3 shows the results of echo chamber measurements for determining the static sound absorption coefficient α according to the method of D1N 52212, whereby 10 like specimens are distributed on 4 cm high wooden frames on the chamber floor.

It was found that in the region of low frequencies, the heaviest element 12 of pure fibre mat was the most effective, whereas at medium frequencies the element 11 according to this invention and the foam-filled component 13 were slightly superior. At high frequencies an approximately equivalent absorption of all three elements was established on average. In the comparison of the results, it must be taken into account that the component 12 washeavier and the component 13 thicker than the component 11.

For comparison of the bending stiffness of the elements, these elements were supported at the edge and each tested in the longitudinal and transverse directions for stiffness, expressed in N/mm^2. The following values were obtained:

Component	Area per Component (m^2)	Mass per Component (g)	Stiffness (N/mm^2) Longi-tudinally	Trans-versely
11	0.81	1800	0.93	5.6
12	0.81	2600	0.84	4.3
13	0.81	1650	0.06	3.9

The great differences between the longitudinal and transverse direction of the stiffness arise from the fact that the mouldings possessed a pressed rib in the transverse direction.

As can be seen, the soft foam element 13 failed completely in the strength test, corresponding to a pronounced sag in one direction. Use as a self-supporting component therefore cannot be considered.

On the other hand, the structure 12, which is approximately equivalent to the element 11 in respect of sound absorption, has a substantially higher weight for approximately four times smaller stiffness.

CLAIMS

1. A self-supporting, generally substantially flat construction element or panel, comprising a support layer, on each of the two outer faces of which a covering layer is disposed characterised in that at least one covering layer is permeable to air, that the support layer has an open-cell structure with cells extending substantially transversely to the faces and the compressive strength of the support layer in the direction transverse to the faces is greater than that of each of the covering layers, whereas the tensile strength of the support layer in the general direction parallel to the faces is smaller than that of each of the covering layers, and in that the support layer is deformed in relief-like manner by compaction or compression at least in the region of the border of the construction element.

2. A construction element according to Claim 1 in which the support layer is in the form of a honeycomb structure the cells or passages of which open to both covering layers.

3. A construction element according to Claim 1 in which the support layer is composed of a plurality of mutually adjoining and connected together corrugated layers, whereby the cavities or passages produced by the corrugations extend from the one external face of the support layer to the other.

4. A construction element according to Claim 2 or 3 in which the support layer is formed from kraft paper or cardboard or a plastics material.

5. A construction element according to Claim 4 in which the support layer is formed from resin impregnated kraft paper or cardboard.

6. A construction element according to any one of the preceding claims in which the air-permeable covering layer is formed as a compacted non-woven fibrous material, bonded with a synthetic resin, preferably a random orientated fibre fleece, needle felt or fulled felt.

7. A construction element according to any one of the preceding claims in which, on one outer face of the support layer, a covering layer formed as thin foil, preferably of kraft paper or cardboard, is disposed.

8. A construction element according to Claim 1 in which at least one of the two covering layers is multi-layered and comprises an air-permeable, compacted non-woven fibrous material bonded with a synthetic resin, preferably a random orientated fibre fleece, needle felt or fulled felt, on the external face of which remote from the support layer a layer of a textile material or a porous PVC foil is disposed.

9. A construction element according to Claim 8 in which the layer of textile material or porous PVC foil is laminated with a foamed layer presented towards the support layer.

10. A construction element according to Claim 1 in which the one covering layer is an air-permeable heavy foil.

11. A construction element according to Claim 1 in which the one covering layer comprises a

fibre-reinforced synthetic resin.

12. A self-supporting construction element constructed and arranged substantially as herein described with reference to Figures 1*a* and 1*b* or Figures 2*a* or 2*b*.

13. A method of making a construction element according to Claim 1 characterised in that all the layers are laid in the predetermined sequence in a heatable press and are compacted, deformed, consolidated and bonded together in the same operation.

14. A method according to Claim 13 in which the compaction of the layers is carried out essentially perpendicularly to the faces and to such an extent that the total thickness of the compacted layers is less than the original thickness of the support layer.

15. A method according to Claim 13 or 14 in which a layer of a textile material or of an air-permeable PVC foil is applied to the air-permeable covering layer.

16. A method acording to Claim 15 in which the layer of textile material or PVC foil is laminated with a foamed layer presented towards the support layer.

17. A method of making a self-supporting construction element substantially as herein described.

18. Use of the construction element according to Claim 1 for passive counteraction of noise and especially for the cladding of the engine space or passenger cabin of an automobile.

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