SOUND ABSORPTION STRUCTURES

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ABSTRACT
Sound absorption assemblies each comprising a plurality of units, each comprising a laterally extending series of vertically extending readily loaded flexible pockets, each holding a weighty particulate mass while permitting some relative motion therein, pockets of one unit complementing the pockets of the adjacent unit.

7 Claims, 29 Drawing Figures
SOUND ABSORPTION STRUCTURES

BACKGROUND OF THE INVENTION

1. Field of the Invention
This invention relates to acoustics and more particularly to baffles with sound absorbing material therein, casing structures for mufflers and sound filters and filling and sound absorbing materials.

2. Description of the Prior Art
The construction and installation of sound control panels has been directed to fabrication at a manufacturing facility of bulky structures and transport thereof to the site of intended use where the bulky panel section is installed in place. The assembly of such panels and handling during manufacture, factory storage, transport, site storage and piece by piece manual installation has been a long standing substantial cost and labor requirement and the physical limitations on such panels because of the practice of manual handling have limited the size and efficiency of such structures. By this invention a readily shipped flexible cover, occupying relatively little storage and transport space, that is readily mounted or located in place and automatically filled is prepared. Not only are these assemblies more readily handled and more easily installed than the structures heretofore used, but also the acoustic efficiency of the structures herein provided, because of the otherwise not readily handled bulk of the sound absorbing structure, provide improved acoustical as well as economic effects.

SUMMARY OF THE INVENTION

Frictional contacts between components of a weighty filler mass is used to effectively stop noise on passage therethrough while the mass is held in a structure formed by combination of a plurality of readily handled plastic receptacles of adequate strength to hold the weighty mass in dimensionally stable form while still permitting frictional movement between the components of that weighty filler mass. The material and dimensions of the carrying pockets are chosen so that the particulate material carried will, with a minimum of interference by the container therefore effectively absorb the sound impinging thereupon. The pockets are in a laterally extending series. Several forms of the pockets and combination of the pockets are provided from simple structural shapes utilizing the adaptability of polyolefin thermoplastics to be formed into tubes with walls of substantial mechanical strength; the vertically extending pockets are formed into a laterally extending series and each series is complemented with other pockets to readily form a vertically and laterally extending acoustic barrier of substantially uniform cross section from top to bottom and side to side.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a horizontal transverse sectional view along the section 1A—1A of FIG. 7 and is a diagrammatic view of a stage in the formation of a unit, 41, of one embodiment of assembly 31 according to this invention.

FIG. 2 is a transverse horizontal cross sectional view along the plane 2A—2A of FIG. 7 and is, like FIG. 1, a showing of the relation of parts during the formation of a portion of one unit, 41, of one embodiment, 31, of this invention.

FIG. 3 is a transverse sectional view, generally along the plane 1A—1A of FIG. 7 during an intermediate stage of handling thereof prior to achievement of the fully distended configuration shown in FIGS. 4, 8 and 9.

FIG. 4 is a transverse horizontal view of one embodiment of apparatus, assembly 31, according to this invention taken along the direction of plane 4A—4A of FIG. 8 and shows the distended, operative, position of the units 41 and 51 forming the assembly 31.

FIG. 5 is an intermediate view of manufacture of an embodiment, 32, according to this invention and corresponding to the stage of manufacture of embodiment 31 shown for FIG. 3.

FIG. 6 is a horizontal transverse cross sectional view of a second embodiment of assembly, 32, of this invention taken along plane 6A—6A of FIG. 20.

FIG. 7 is a frontal view of unit 41 taken along the direction of arrow 7A of FIG. 2.

FIG. 8 is a frontal view of assembly 31 along the direction of arrow 8A of FIG. 4. 1.

FIG. 9 is a longitudinal transverse cross section view along plane 9A—9A of FIG. 4.

FIG. 10 is a variant of the embodiment of unit 41 as seen along the direction of arrow 10A of FIG. 1.

FIG. 11 is a horizontal transverse sectional view along the plane 11A—11A of FIG. 17 and is a diagrammatic view of a stage in the formation of a unit 141 for assemblies 33 and 34 according to this invention.

FIG. 12 is a transverse horizontal cross sectional view taken along the plane 12A—12A of FIG. 17 of the flattened unit 141.

FIG. 13 is a horizontal transverse sectional view of component units of embodiment 33 according to this invention shown in a slightly distended view.

FIG. 14 is a horizontal transverse sectional view, along plane 14A—14A of FIG. 18, of the embodiment 33 in the fully distended, operative, position thereof.

FIG. 15 is a horizontal transverse sectional view of component units of embodiment 34 in a slightly distended condition.

FIG. 16 is a transverse horizontal sectional view of the embodiment 34 along plane 16A—16A of FIG. 21, in fully distended operating position thereof.

FIG. 17 is a frontal view taken along the direction of the arrow 17A of FIGS. 11 and 12 of unit 141.

FIG. 18 is a frontal view of the assembly 33 as seen along the direction of the arrow 18A of FIG. 14.

FIG. 19 is a vertical transverse section, along the plane 19A—19A of FIG. 14, of assembly 33.

FIG. 20 is a frontal view, along the direction of the arrow 20A in FIG. 6, of unit 32.

FIG. 21 is a frontal view, along the direction of the arrow 21A of FIG. 16, of assembly 34.

FIG. 22 is a transverse vertical section along plane 22A—22A of FIG. 6 of assembly 32.

FIG. 23 is a vertical transverse sectional view, along plane 23A—23A of FIG. 16, of embodiment 34.

FIG. 24 is a frontal view, along the direction 17A of FIG. 11, of the flattened component 441 from which the assembly 34 shown in FIG. 15 is formed.

FIG. 25 is a perspective broken away view of bottom of assembly 31, partly in section and diagrammatic.

FIG. 26 shows a broken away view of the construction of the composite sheet 89 to diagrammatically show its internal structure.

FIG. 27 is a frontal view of unit 841 taken along direction of arrow 7A of FIG. 2.

FIG. 28 is a frontal view of assembly 831 (a variant of assembly 31).

FIG. 29 is a perspective view of assembly 831.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In general this invention comprises a related series of acoustical barrier panel assemblies. Four separate embodiments are described and shown as assemblies 31, 32, 33 and 34 respectively. Assembly 31 is shown in FIGS. 4, 8 and 9; assembly 32 is shown in FIGS. 6 and 20; assembly 33 is shown in FIGS. 14 and 18 and assembly 34 is shown in FIGS. 16 and 21. Variants of components 41 and 141 are in FIGS. 10 and 24 respectively.

Each of these assemblies comprises a plurality of units, each such unit comprises a laterally extending series of vertically extending flexible pockets; each of these pockets have closed bottoms and is filled with particulate material and the general array of the units forming the assemblies 31 and 32 is that the
filled pockets in each of these units are staggered relative to the filled pockets of another unit of the assembly so that the filled pockets of the second unit interdigitate with the filled pockets of the first unit. The use of the staggered arrangement of the filled flutes in the units (as 51 and 41 for assembly 31 and 151 and 141 for assembly 32) provide for a complete mechanical blocking and as complete an acoustical blocking as may be desired between the interior of a room 77 and the wall therefor as 76. The benefits of such improved acoustics is particularly important in heavy manufacturing buildings where noise concomitant on forceful manufacturing steps are developed, and the reverberations otherwise present in walls of simple structure would be detrimental to efficient working in such structures by human beings. Each of the pockets carry a sound absorbing particulate weighty mass, the specific gravity of which is greater than two and the carrying by these pockets is so performed that relative motion of this particulate material in the pockets results on impingement of sound on the outside of such pockets whereby acoustical damping is effected by the material so held. The flexible pockets are in two embodiments, when empty, as shown in FIGS. 7 and 17, somewhat wider at their top than at their bottom; insofar as there is a distension provided to the pocket material by the weight of the filling material, in their distended arrangement as shown in FIGS. 4 and 14, the distension of the material forming the walls of the pockets provides a somewhat larger dimension to the loaded pocket than in the empty pocket so that each loaded pocket has the same transverse horizontal cross section at its bottom as at its top. In other embodiments, shown in FIGS. 10 and 24, the pocket walls are made of materials of sufficient strength that there is no appreciable distension of the pocket by the weight of the filling material and such embodiment using such structural also has the same transverse horizontal cross section at its bottom and at its top. The material and dimensions of which the pockets are made are related and arranged to provide a substantially uniform horizontal acoustical cross section through the assembly from the top to the bottom. The material of the pockets may, according to one embodiment of this invention, be not uniform in tensile strength throughout the cross section thereof, as shown in FIG. 26. Assembly 31, according to this invention comprises a first unit 41 and a second unit 51 operatively arranged as shown in FIGS. 4, 8 and 9 of the drawings. Each unit as 41 is composed of sheets 42 and 43 joined together to form series of like flutes as 71, 71′, 71″ and 71‴ and a hanging strip as 72. Units 41 and 51 are identical in size and shape and are used with the flutes thereof as 71, 71′, 71″ and 71‴ respectively in staggered and interdigitating relationship. Unit 341 is a variant of unit 41. The unit 41 initially comprises a first or rear reinforced flat thermo-plastic polystyrene sheet, 42, and a second like front plastic sheet 43 which are firmly joined together, as by heat fusing, along straight lines. In embodiment of FIGS. 1, 2 and 7 there junction lines are in the form of a triangle; in the unit 341 shown in FIG. 10 such junction lines are vertical and parallel and on each side of each flute, and referent numerals 300 units higher are used for components corresponding to like parts of unit 41. The rear sheet 42 has a front contacting surface, 44, a portion of which is, during the initial stage of manufacture of the unit 41, in direct contact with the rear surface 45 of the front sheet 43. The sheets 42 and 43 are joined together at regularly spaced apart points at their top, as at 46 and 46′, for each of the series of flutes as 71 (and 46′ and 46″ for flute 71′); the sheets 42 and 43 are also joined together at a bottom left point 47 and a bottom right point as 48 shown in FIGS. 2 and 7, as well as in a complete continuous triangular strip 49 extending from the top fuse point 46 to the bottom fuse points 47 and 48 in the FIG. 7 embodiment. The sheets 42 and 43 of each unit as 41 are joined together as by fusing along a straight line at their bottom edge edge 50 to form a laterally extending series of vertically extending pockets or flutes as 71, each of which is closed at such bottom edge as 50 but open at the top edge to form an upper, opening, as 70 for each flute as 71. Corresponding parts of flutes 71′ and 71″ are numbered with corresponding numbers (as 46′, 47″, 48″, 49″ and corresponding superscripts as "′", "″"). The unit 51 comprises a series of like flutes as 73, 73′ and 73″ equal in width and height to the flutes as 71, 71′ and 71″ of unit 41 and a hanging strip 74 of same size as strip 72. This series of flutes and hanging strip is formed as for unit 41 from a pair of matching sheets 52 and 53 identical to sheets 42 and 43 in structure and composition. The rear sheet, 52, is provided with a front contact surface 54 which in its formation initially contacts the rear contact surface 55 of the sheet 53. These sheets 52 and 53 are formed of the same sheet material used for unit 41 and are joined together as by fusion points at their top as 56 and at points as 57 and 58 at their bottom. The points 57 and 58 are slightly spaced apart from each other in the horizontal plane and a continuous vertically extending triangular strip 59 identical to strip 49 joins points 56, 57 and 58. The sheets 42 and 43 as well as 52 and 53 are formed of two like flexible plastic sheets 84 and 85 with a fibrous net 86 laminated therebetween to form a reinforced composite sheet 89. The net is formed of a strong evenly spaced horizontal fibers 82 and likewise evenly spaced vertical fibers 83 and has a greater tensile strength than the sheets. The fillers are preferably of a thermoplastic material as high density polyethylene or polypropylene, the sheets and the net are fused together throughout the area of the surface of the net and the sheets are fused together throughout their common surface. Sheet 89 is accordingly a composite sheet with a tensile strength that is not the same across each very small increment of a cross section thereof although it does have, over each 2 inch length a substantially uniform cross sectional strength. The flutes as 71 and 171 are usually 4 to 12 inches in diameter in operative embodiments. The flexible sheets 84 and 85, are, in a preferred embodiment, formed of polypropylene. The net fibers as 82 and 82′ extend vertically while fibers as 83 and 83′ extend horizontally; these fibers extend for the full length of the flutes as 71 and 73 and the horizontal fibers run the full width of each of the flutes from one vertical strip as 49 to a corresponding vertical strip 49″ on either side of a flute as 71. The rear surface of sheet 42 is referred to as a rear surface 60 and the front surface of sheet 43 is referred to as front surface 61. The rear surface of sheet 52 is referred to as rear surface 62 thereof and the front surface of sheet 53 is referred to as surface 63. In operation rocky particulate material as 81 is put into each of the pockets, as pockets 64, 64′ and 64″ formed by the flutes 71, 71′ and 71″ respectively of unit 41, and in pockets 65, 65′ and 65″ formed by each of the flutes 73, 73′ and 73″ of the sheets forming unit 51. The particulate filling material is limestone with a size distribution as in Table I and a specific gravity of 2.6. 

<table>
<thead>
<tr>
<th>Mesh Size</th>
<th>Percent Passing Screen</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>99</td>
</tr>
<tr>
<td>8</td>
<td>76.5</td>
</tr>
<tr>
<td>14</td>
<td>54.0</td>
</tr>
<tr>
<td>28</td>
<td>23.3</td>
</tr>
<tr>
<td>48</td>
<td>10.0</td>
</tr>
</tbody>
</table>

This size distribution of particles provide a sufficiently low amount of "fines" (~25 mesh particles) to avoid packing of such small particles in high humidity conditions while still providing sufficient amount of surface per unit volume to provide efficient sound absorption by the above discussed friction action of such particles.
In operation of the unit 31 the thus filled flutes of unit 41 and unit 51 are each supported on a hanger or beam as 75, which hanger or beam is above the ceiling 79 of the room 77 and adjacent to the wall 76 of that room and above the floor 78 of that room. The front portions of the unit 41 then contact the adjacent portion of the rear surface of the wall of the surface 62 and there is some flattening at such areas of contact as 66, 69, 69", 67, 67". Assembly 31 thus provides a heavy continuous mass between the interior of the room 77 and the wall 76. The cross section through such composite assembly 31 of the units 41 and 51 varies only slightly from its maximum section 9A—9A in FIG. 4 and to its minimum, the diameter of one distended flute as 71 or 73 of a single unit as 51 or 41.

As the bottom of each of the units as 41 and 51 is straight, the bottom of the flutes thereof provides a shape as shown in FIG. 25 that resembles a bottom of a toothpaste tube. The bolsters 87 and 88 are in firm contact with the floor 78 and with the bottom of the flutes as 71 and 73, and, in cooperation therewith, provide a substantially even acoustical cross section through the bottom portion of the assembly 31 transverse to the lateral length thereof. Similarly, the most bottom portion of each of the flutes in each of the assemblies as 32, 33 and 34 are complemented to provide a barrier of substantially uniform cross section. The bolsters 87 and 88 are flexible tubes of thermoplastic laminate 89 filled with filling material 81 as in the units 41 and 51 and closed at their ends. The bolsters are of sufficient diameter to contact the sloped bottom portion of the front or rear surface, as 63 or 60, of the flutes of the assemblies and the floor therebellow.

Embodiment 33 comprises a pair of like units 141, 241, 151 arranged as in FIGS. 14 and 18 and formed as in FIGS. 11, 12 and 17. Generally in the embodiment shown as 33 the structure for unit 31 shown in FIG. 1 and 2 and 7 is modified by changing the strips as 49 from a triangular shape to a strip of trapezoidal shape as 149 and 149' as in FIG. 17 or rectangular shape as in FIG. 24 and, thereby an acoustical barrier is formed of a series of laterally extending interdigitating pockets of uniform horizontal transverse cross section from top to bottom and of relatively even cross section from side to side. Each unit as 141 is composed of sheets 142 and 143 joined together to form a series of like flutes as 171, 171', 171" and 171''' and a hanging strap as 172. Units 141, 241, 151 are identical in size and shape and are used with the flutes thereof as 171, 171', 171" and 171''' and a hanging strap as 172. Units 141, 241, 151 are identical in size and shape and are used with the flutes thereof as 171, 171', 171" and 171''' and a hanging strap as 172. Units 141, 241, 151 are identical in size and shape and are used with the flutes thereof as 171, 171', 171" and 171''' and a hanging strap as 172. Units 141, 241, 151 are identical in size and shape and are used with the flutes thereof as 171, 171', 171" and 171''' and a hanging strap as 172. Units 141, 241, 151 are identical in size and shape and are used with the flutes thereof as 171, 171', 171" and 171''' and a hanging strap as 172. Units 141, 241, 151 are identical in size and shape and are used with the flutes thereof as 171, 171', 171" and 171''' and a hanging strap as 172. Units 141, 241, 151 are identical in size and shape and are used with the flutes thereof as 171, 171', 171" and 171''' and a hanging strap as 172. Units 141, 241, 151 are identical in size and shape and are used with the flutes thereof as 171, 171', 171" and 171''' and a hanging strap as 172. Units 141, 241, 151 are identical in size and shape and are used with the flutes thereof as 171, 171', 171" and 171''' and a hanging strap as 172.
same, namely by adding vertically extending strip between each of the adjacent flutes of any one unit.

In embodiments 32 and 34 the pockets as 371 and 471 are constructed from of material as laminar 89 with sufficient tensile strength in units as 41 and 141 so that there is no appreciable distortion, i.e. a total distortion of less than one-eighth inch at the bottom of the pockets. This is readily accomplished when one considers that an 8 ft. high column of material of a specific gravity of about 2 provides a vertical pressure of only about 8 pounds per square inch and, accordingly, with a circular shape of flutes as 371 and 471 (as well as 71 and 171) develops a surprisingly small peripheral tensile stress, i.e. only about 16 p.s.i. A homogenous polypropylene sheet with a tensile strength of over 4,000 p.s.i. is adequate in thickness of 0.010 inches to maintain a dimensionally stable flute, while thermoplastic, to permit forming of flutes as above described.

Accordingly, in the embodiments 32 and 34 the empty flutes as 371 and 471 have a rectangular shape as shown in FIGS. 10 and 24 rather than trapezoidal as in FIGS. 7 and 17 and, as above discussed, embodiments 31 and 33 may also be made from units as 341 and 441 (as well as from units 41 and 141) with such rectangular flutes. The use of the heterogeneous laminate 89 readily also provides such overall tensile strength and is preferable as a wall material as hereinbefore explained.

In assembly 32 the flutes 371, 371' and 371'' are the same as and correspond to the flutes as 71, 71' and 71'' of the unit 41 and those flutes are as shown in FIGS. 1, 3 and 10. The triangular shaped strips as 49, 49' of unit 41 shown in FIG. 7 are replaced by parallel vertical lines of fusion as 40, 40' and 40'' joining sheets 42 and 43, as the sheet material of assembly 33 has a sufficiently high modulus of elasticity to provide no appreciable distension in filling of the flutes thereof with filling material. The bottom edge 350 joins the bottom of flutes as 371 and 371' by joining sheets 42 and 43.

In the embodiment 32, (FIGS. 6 and 19), vertically extending strip 92, 92' 92'', 93, 93' 93'' of thermoplastic material identical to that in unit 41 are added between the flutes 371, 371' and 371''. In assembly 32, the lateral edges of each of the strips 92, 92' and 92'' are firmly attached, as by fusion to the flutes 271, 271' and 271'' (corresponding to flutes 71, 71' and 71'') in a structure as shown to scale in FIGS. 5 and 6. Fusion may be by heat or ultrasonics.

In the manufacture of the apparatus of FIGS. 6 and 20 the unit 41 such as shown in FIG. 1 and 10 is inflated only slightly to the position shown in that of FIG. 3 and, in such orientation of parts, strips of thermoplastic polyolefin, as polypropylene, as 92, 92' and 92'' are attached to the rear surface as 60 of the structure shown in FIG. 3 to create a structure as shown in FIG. 5 composed of a series of like flutes 371, 371' and 371'' with the rear surface (as 60) of each of the flutes shown in FIG. 3 provided with a strip as 92 to the rear surface of the adjacent flute and the front surface (as 61 shown in FIGS. 5 and 3) is joined by a strip as 93 extending to the front surface of the adjacent flute. A cavity as 292 is formed between flutes as 371 and 371' and strip 92 and a cavity as 293 is formed between adjacent flutes as 371 and 371' and each strip as 93.

The addition of rocky particulate material as 81 to the orifice 270 of the resulting fluted structure provides that the pockets as 292 and 293 adjacent flutes as 371 and 371' provide for an equalization of the horizontal path transverse of the width of unit 32 through the laterally extending series of vertically extending pockets in a single structure rather than using the plural structure of assembly 33 or 31 above discussed.

In embodiment 34 the unit 141, composed of flutes as 171, 171' and 171'' with corresponding rectangular web shaped elements as 449 and 449' shown in FIGS. 11 and 24, has strips as 94', 94'' 95, 95' and 95'' attached to the flutes as by ultrasonics or heat while in a slightly expanded, as in FIG. 14, position whereby a series of additional pockets as 494, 494', 494'', 495, 495', 495'' and 495'' are provided as shown in FIGS. 15 and 16.

Embodiment 34 is also a single integral structure providing a laterally extending series of interdigitating vertically extending readily loaded flexible pockets having closed bottoms and which carry particulate weighty masses therein of a specific gravity greater than 2.

Embodiment 34 comprises a modified unit 141 arranged as in FIGS. 16 and 21 and formed as in FIGS. 11 and 15.

Generally, in the embodiment shown as 34 the structure for unit 33 shown in FIG. 12 and 17 is modified by changing strips 149 (FIG. 17) from a trapezoidal shape a strip of rectangular shape strip as 449 and 449' as shown in FIG. 24 and adding strips as 94', 94'', 95 and 95'', thereby an acoustical barrier is formed of a series of laterally extending interdigitating pockets of uniform horizontal transverse cross section from top to bottom and of relatively even cross section from side to side. Assembly 34 is formed from a unit as 441 (FIG. 24).

Each unit as 441 is composed of sheets 442 and 443 joined together to form a series of like flutes as 471, 471' and 471'' and a hanging strip as 474. Unit 441 is identical to the units used in assembly 33 when a sufficiently strong plastic sheet is used for the formation of the pockets thereof (in unit 141 in lieu of unit 141 (and 151). The unit 441, in its initial form, comprises a single reinforced flat thermoplastic polypropylene sheet, 442, and a second like front plastic sheet 443 which are firmly joined together, as by heat fusing, along straight lines. As shown in FIG. 24 these straight lines are vertical and parallel on each side of each flute. Ultrasonic fusing may also be used.

The rear sheet 442 has a front contacting surface, 444, a portion of which is, during the initial stage of manufacture of the subassembly 441, in direct contact with the rear surface 445 of the front sheet 443. The sheets 442 and 443 are joined (fused) together at regularly spaced apart points at their top, as at 485 and 446, for each of the series of flutes as 471 (and 485' and 446' for flute 471') the sheets 442 and 443 are also joined (fused) firmly together at a bottom left point 447 and a bottom right point as 448 shown in FIGS. 24 as well as in a complete continuous rectangular strip as 449 extending from the top point as 446 and 485' to the bottom fuse point as 447 and 448.

The sheets 442 and 443 and flaps 94, 94', 94'', 95, 95' and 95'' of each unit as 441 are joined together, as by fusing, along a straight line at their bottom edge 450 to form a laterally extending series of vertically extending pockets or flutes as 471, 494 and 495, each of which is closed at such bottom edge as 450 but open at the top edge to form an upper opening, as 470 for each flute as 471, and 496' and 497'' for pockets 494' and 495''. (Corresponding parts of flutes 471 and 171 491 and 495 are numbered with corresponding numbers as 446', 447', 449', 449', 494' and 495' and corresponding superscripts as ' and ''). Except for difference in strength and shape of web 449, unit 441 is identical to unit 141 and the components thereof are given referent numerals 300 units higher than the corresponding components in unit 141.

The sheets 442 and 443 are formed of strong flexible plastic sheets as 84 with cross fibers as 82 and 83 laminated therebetween. The flexible sheet 84 is, in a preferred embodiment, formed of polypropylene with the fibers 82 running in a vertical direction while fibers 83 run in the horizontal direction. These fibers extend for the full length of the flutes as 471, 494, 495, 471', 494' and 495' and the horizontal fibers run the full width of each of the flutes from one vertical strip as 449 to a corresponding vertical strip 449' on either side of a flute as 471'. The flaps 94, 94', 94'', 95, 95' and 95'' form pockets 494, 494', 495, 495' and 495'' respectively in as assembly 34. In operation rocky particulate sound absorbing material as 81 is put into each of the pockets formed by the flutes 471, 471' and 471'' respectively of unit 441, and in pockets formed by each of the flutes 473, 473' and 473'' of unit 441 and in pockets formed by flutes 495, 495' and 495'' of assembly 34.
The filler material 81 is limestone and the size distribution is as in Table I. In operation of the unit 34, the thus filled flutes of units 441, and 141, 144, 94', 95' and 94'' are each supported on a hanger or beam as 75 which hanger or beam is above the ceiling 79 of the room 77 and adjacent to the wall 76 of that room and above the floor 78 of that room. The front and rear portions for the subassembly 441 then contacts the adjacent portion of the rear of flutes as 494 and 494' and 495' and 495'' and there is some flattening at such areas as 466, 466', 466'', 467, 467' and 467''. Assembly 34 thus provides a heavy continuous mass between the interior of the room 77 and the wall 76. The cross section through such composite assembly 34 varies only from the maximum section 23A—23A in FIGS. 16 and 23 to the minimum cross section diameter of one distended flute as 371 of the single unit as 441. The variation is from 100 percent of maximum to 70 percent of maximum.

As the bottom of each of the units as 141 and 151 and 241 is straight, the bottom of the flutes thereof provides a shape as shown in FIG. 23 that resembles a bottom of a toothpaste tube. The bolsters 87 and 88 are in film contact with the floor 78 and with the sloped portion of the bottom of the flutes as 471 494 and 495, and, in cooperation therewith, provide a substantially even acoustical cross section through the most bottom portion of the assembly 34 transverse to the lateral length thereof.

Preferably the walls of the pockets of units of assemblies 31—34 are made of the relatively heterogenous laminate material 89 wherein the net as 86 has a greater tensile strength than the sheets 84 and 85 and its overall strength or thickness is great enough to suffer no distortion or creep under the weight of filling material carried by such pockets. Then fibers 82 and 83 of the pocket take most of the mechanical load without substantial distortion so that the bulk of the load of filling material 81 is supported by the net of strong fibers as 82 and 83; the plastic sheeting which is between the fibers and of lower tensile strength is, thus, slightly distensible (relative to the fibers), providing support mainly only between the fibrous material although still maintaining a firm yet flexible contact with the finely divided, sand-sized material therein over substantially the entire peripheral area thereof. Thereby sound waves impinging on such heterogenous flexible wall material is effectively passed therethrough into the particulate mass held within the cavity of such flute and the sound waves will vary very effectively cause the units of the particulate mass 81 in the pockets to move slightly against each other and absorb a substantial acoustic energy as 341 by fusing together the outer pocket wall while the substantial surfaces of contact as 66, 66', 166, 166', and the like of the adjacent pockets of adjacent units serve to utilize the full mass of the filling material for such acoustic energy absorption. When the net 85 of wall has the strength to support its filling, as 81, without distortion and the sheet material does suffer some elastic distortion in carrying such load, the absorption of acoustic energy is particularly efficient.

The spacing of fibers as 82 and 83 is preferably one-half inch; polypropylene is preferably used as it has a particularly high flexibility, abrasion and cut-through resistance, and its tear resistance is particularly improved by the reinforcement by fibers as 82 and 83 above discussed.

As shown by the FIGS. 4, 6 and 16, which are drawn substantially to scale in regard to the shapes of the filled flutes each assembly there shown, (although the wall thickness is exaggerated for illustrative purposes) the variation from minimum to maximum transverse thickness of those assemblies is in range of from 100 to 150 percent the minimum thickness of the flutes.

In operation the units as 41, 42, 141, 142, 241 are mounted on the support thereon, as bracket or stud 75 and thereafter the flutes are automatically filled by conveyors that empty filling material 81 into the orifice as 70 of each flute as 71. The filling material causes the flute to expand to the shapes shown therefor in FIGS. 4, 6, 14 and 16.

While the above description has been directed to thermoplastic polyolefins it is, within the scope of the structures herein disclosed, that other thermoplastics of adequate tensile strength as above described may be used and that other flexible materials may be used with conventional methods of bonding of such reinforced plastic (as set out in Section XII—10, Bonding, of Handbook of Reinforced Plastics of The Society of Plastics Industry, Oleksy and Mohr, Reinhold Publishing Corp., 1964).

With use of conventional reinforced plastics teaching to provide sheet material of variable strength, as measured by tensile strength and Young's Modulus, along the height of the flutes of the assemblies 31—34 with the reinforcement added to provide increasing strength with increasing depth of pocket, the same degree or absence of distension can be achieved along the height of each of the loaded flutes and so provide a more uniform acoustic response along the entire height of each flute as well as a uniform horizontally transverse cross sectional area of the assembly. For example, the reinforcing fibers as 82 and 83 of the net 86 may be, according to this invention, more closely spaced at the bottom of the flutes than at the top, with the spacing varying inversely as the height of the flute. Further, other reinforcement material, such as rovings and non-woven fabrics or thin mats may be distributed through the plastic to provide the desired differential strength characteristics to provide the structural and dimensional characteristics for the acoustical characteristics hereinafore described. The bolsters as 87 and 88 extend for the full width of the assemblies, as 31—34, with which used as shown in the drawings and as above described.

The invention also includes, in a variant of embodiment 31, which variant is shown in FIGS. 27—29 as 831, joining the front sheet 842 and 843 of unit 831, corresponding to front sheet as 42 and the rear sheet as 43 in the embodiment 31 and likewise for assembly 851) at their upper portion only at the lateral edges, as 801 and 802 and leaving in each unit as 841 and 851 of embodiment 831 upper laterally extending areas 872 (corresponding to strip 72 in unit 31 and 372 in unit 341) and an equally wide and deep strip 812 on the sheet 843 (corresponding to sheet 243 of unit 41 and 343 of unit 341) about 1 foot high and free of junction between the sheets as 842 and 843 so that the upper area 68 (top sheet 842 and 843) above the line 870 forms a laterally extending pocket or funnel (68) when the article, as unit 841 is suspended from its strip, as 872. The pockets and flutes as 871, 871' and 871'' are formed, as 71, 71' and 71'' as in embodiment 31 and units 41, 42, 141, 142 and 241 by fusing together the outer pocket wall while the substantial surfaces of contact as 846, 846', 847, 847' and 847'' (like 846', 847' and 847'') as 849, 849', 849' like 49, 49', 49'' in unit 41 or along straight lines, as 40, 40', 40'' in unit 341 upward from the bottom edge 850 (as at 50 in unit 41) to the line 870 of the bottom of the laterally extending pocket 868. The top end, opening 68 (as at 70 in 41) of each flute opens into the bottom of such pocket or funnel 868.

This structure provides, as shown in FIG. 29, an acoustical barrier assembly comprising a laterally extending series of vertically extending flutes or pockets as 871, 871', 871'', each pocket formed of flexible sheet material as 89 and filled with particulate material as 81, said pockets or flutes each having a uniform horizontal transverse cross-section from its opening at its top near to the bottom of such flute, and each such series, as shown for assembly 31, interdigitates with filled pockets or flutes of a like other series of pockets forming the assembly 831 and wherein a laterally extending open topper funnel 868 extends across the top of said pockets as 871, 871' and 871'' and the sheet material forming the pockets as 871, 871' and 871'' is continuous with the sheet material forming the funnel, as 868.

In operation, granular material is poured into the funnel as 68 in FIG. 29 to fill the flutes as 871, 871' and 871'' (corresponding otherwise to flutes as 71, 71' and 72'' in unit 41 and 371, 371' and 341). Thereby the flutes are particularly
quickly and easily filled as well as that the group of flutes and the funnel therefor is readily formed from two sheets as for units 41 and 341.

1 claim:

An acoustical barrier panel comprising a laterally extending continuous series of vertically extending pockets, each said pocket formed of a flexible sheet material sleeve filled with particulate material, said pockets each having a uniform transverse cross section from its top to near to its bottom, said particulate material being a sound-absorbing material, and wherein each adjacent pocket of said series is joined to a plurality of pockets and the thickness through said series does not vary more than 50 percent its minimum transverse thickness, and also comprising a transversely extending sound-absorbing unit below the bottom of said pockets of said series, the bottom of said pockets contacting the top of said transversely extending unit, said transversely extending unit comprising a flexible sheet material cover filled with said particulate sound-absorbing material, said barrier panel located in a room having a floor and a ceiling, said barrier panel supported at its top and extending vertically toward the floor, the transversely extending unit having one surface thereof resting on the floor and another surface thereof contacting the bottom of said pockets.

2. Apparatus as in claim 1 wherein the pockets are formed of a reinforced composite laminated sheet material, two components of which are joined together and have different tensile strengths.

3. Apparatus as in claim 2 wherein one component of the said composite sheet material is elastically distended by the weight of filling material in contact therewith and another component of said composite material extends for the length of said pockets and is not distended by the said weight of said filling material.

4. Apparatus as in claim 3 wherein the specific gravity of the filling material is greater than 2.

5. An acoustical barrier assembly as in claim 1 wherein each of said pockets is connected to a pocket on either side thereof by a web.

6. An acoustical barrier comprising a plurality of panel assemblies each assembly comprising a laterally extending continuous series of vertically extending pockets, each said pocket formed of a flexible sheet material, sleeve villed with particulate material, said pockets each having a uniform transverse cross section from its top to near to its bottom, said particulate material being a sound-absorbing material and wherein the filled pockets of one of said series of pockets contact and interdigitate with the filled pockets or another of said series of pockets and the front to rear transverse thickness through said barrier does not vary from side to side more than 50 percent of its minimum transverse thickness, and wherein the pocket walls are formed of a reinforced laminate composite sheet material, two components of which are mechanically joined and have different tensile strengths, one component of the said composite sheet material is elastically distended by the weight of filling material in contact therewith and another component of said composite material extends for the vertical length of said pocket and is not distended by the said weight of said filling material, and a transversely extending sound-absorbing unit below the bottom of said pockets of said series, the bottom of said pockets contacting the top of said transversely extending unit, said transversely extending unit comprising a flexible sheet material cover filled with said particulate sound-absorbing material, said barrier panel located in a room having a floor and a ceiling, said barrier panel supported at its top and extending vertically toward the floor, the transversely extending unit having one surface thereof resting on the floor and another surface thereof contacting the bottom of said pockets.

7. Apparatus as in claim 6 wherein a laterally extending open topped funnel extends across the top of said pockets of said series, said funnel being open at its bottom to each of said pockets, and is formed of sheet material and the sheet material forming said pockets is continuous with the sheet material forming said funnel.