Aug. 27, 1968 R. E. MULLER 3,398,811

ACOUSTICAL TILE WITH VIBRATILE MEMBRANE EXTENDING INTO FISSURES

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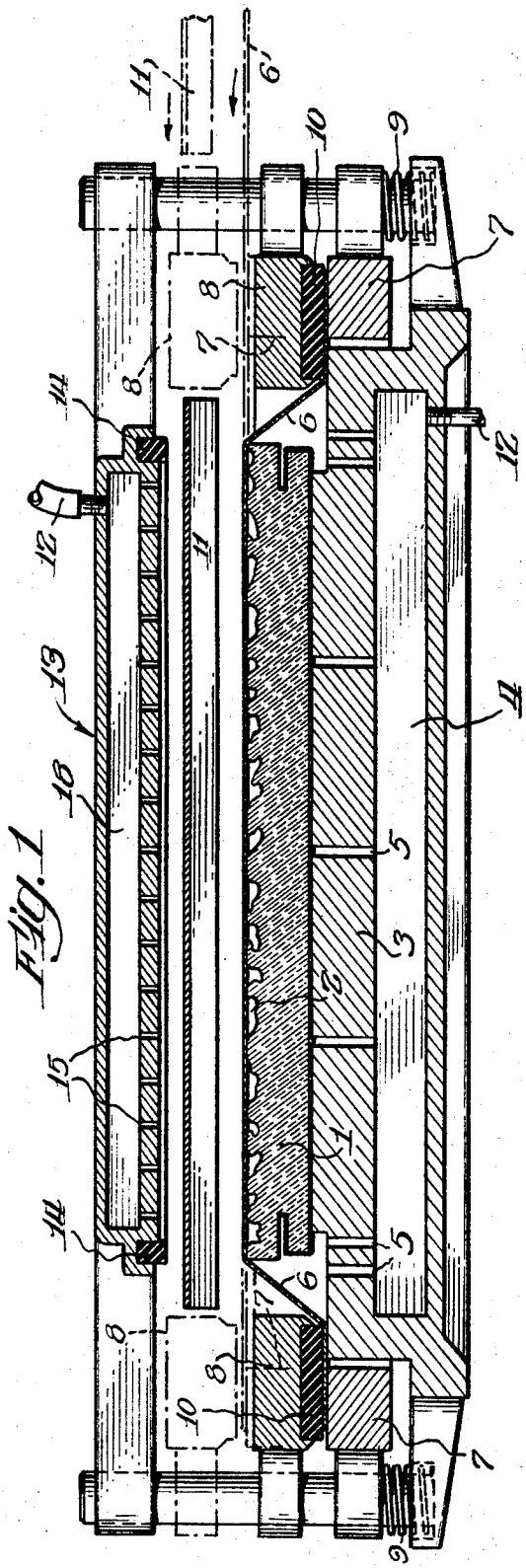


Fig. 1

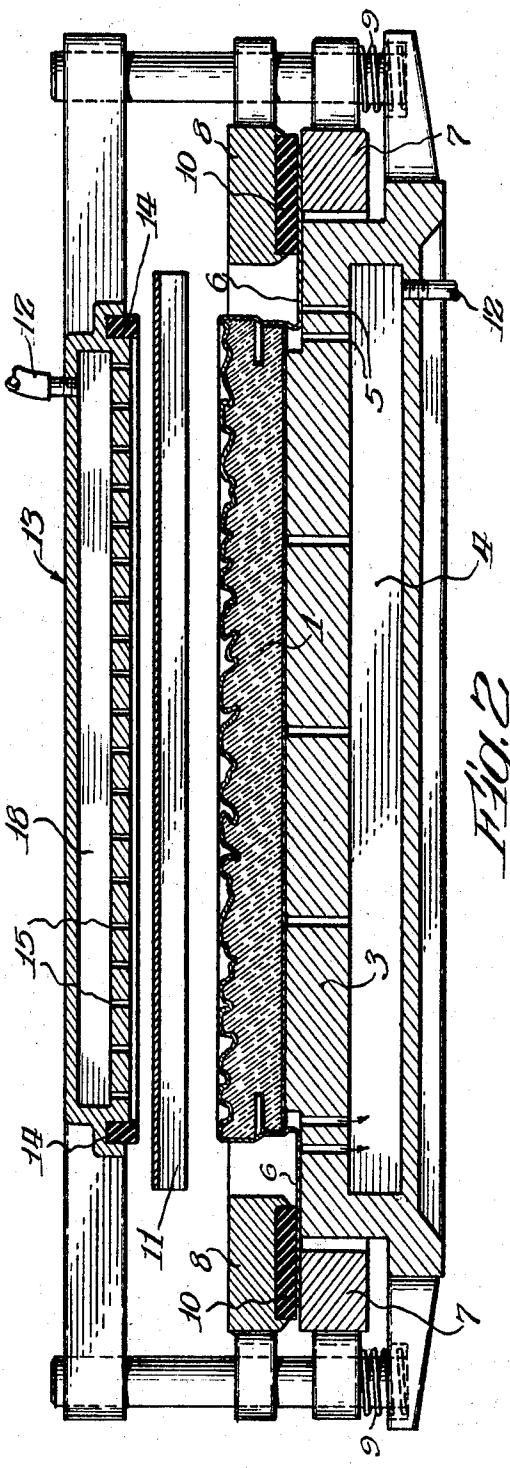


Fig. 2

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ACOUSTICAL TILE WITH VIBRATILE MEMBRANE EXTENDING INTO FISSURES

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Fig. 3

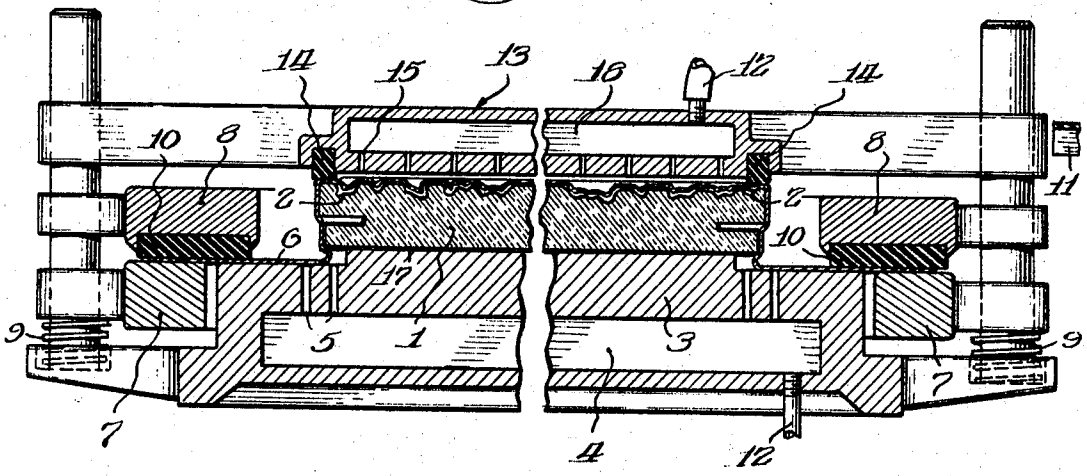
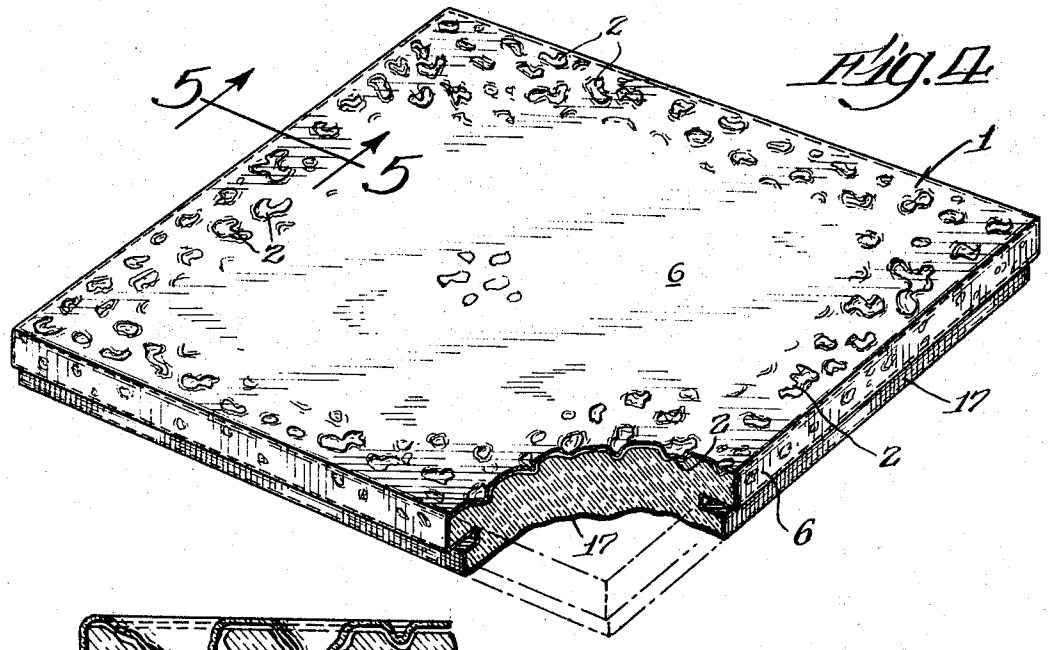


Fig. 4



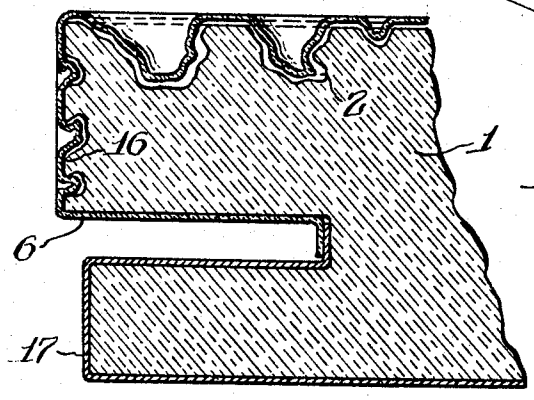


Fig. 5

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3,398,811

ACOUSTICAL TILE WITH VIBRATILE MEMBRANE EXTENDING INTO FISSURES

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ABSTRACT OF THE DISCLOSURE

A fissured acoustical sheet or tile is covered with a vibratile plastic film. The film is free to vibrate relative to the fissured surface over which disposed and is formed so as to comply with the fissures of said surface. The plastic film is fixedly secured to the sheet edge portions.

This invention relates to an acoustical tile and more particularly to one of improved surface characteristics.

There are a number of types of acoustical tile now being used for the sound treatment of surfaces which in addition achieve various novel and pleasing decorative effects. One very popular type is that known as a fissured mineral fiber tile made similar to that described in Patent No. 1,769,519. This product is formed by bonding nodules of mineral wool with a suitable adhesive, such as a starch gel. The mixture is formed into slabs which are hardened by baking or drying after which the face surface of the slab is removed by sanding. This exposes fissures in the surface which provide a novel and pleasing appearance. The slabs are cut into various sizes to form tile. Recently the tile has been further improved by forming the slabs upon aluminum foil which is retained as the back surface. Many attempts have been made to duplicate these pleasing fissures mechanically; however, due to the repetitive nature of such mechanically induced fissures, the surface appearance is not as satisfactory.

While the surface of the tile formed by sanding is very pleasing, it has the disadvantage of being soft, open and porous. This is necessary to give a good sound absorption value. Hence, the surface is easily soiled as it is highly absorptive of dirt. Due to its soft and porous nature, it is very difficult to remove this dirt by washing or other means without injuring the tile. Although a decorative coating can be applied to the surface, it gives only temporary improvement as it again becomes soiled, thus necessitating the use of additional coats which may materially reduce the sound absorbency.

It is possible to extend a plastic film across the surface of the tile and markedly enhance the cleanability without too great a decrease in the sound absorption value. In addition, such films can contribute pleasing designs to the surface of the tile; however, a plastic film used in that manner covers the fissures and the pleasing fissured appearance is lost. Up to the present time no successful way has been found to cover a fissured tile with a membrane and still retain the pleasing fissured appearance. If some means could be devised by which the acoustical properties of these various types of fissured tiles could be retained and at the same time the cleanability improved, a decided advance in the art would ensue.

Therefore, it is an object of this invention to set forth an improved fissured tile having a surface which substantially maintains its original appearance but has improved permanence and washability.

It is a further object of this invention to disclose an enclosed fissured acoustical tile in which a membrane upon its surface reveals the fissured appearance without a substantial reduction in sound absorption.

It is an additional object of this invention to set forth

a fissured acoustical tile in which a thin plastic film extends over the exposed surface thereof and into the fissures without materially reducing the sound absorption properties.

It is an added object of this invention to set forth means for covering a fissured acoustical tile with a membrane which is in loose contact with the surface of the tile but still free from sagging.

It is also an object of this invention to set forth a process for applying a membrane or film of plastic to the surface of a fissured acoustical tile such that the over-all fissured appearance is preserved without a great loss in sound absorbing properties.

It is a further object of this invention to disclose an apparatus for applying a membrane to the surface of fissured acoustical tile by means of which the membrane is drawn into the fissures and to provide means for loosening the membrane from the surface.

Various other objects will readily occur to those skilled in the art of which this invention is a part. This invention is best understood by means of drawings in which

FIGURE 1 is a sectional view of an apparatus depicting a heat softened plastic film clamped into a taut position over the tile.

FIGURE 2 is a similar to FIGURE 1 and shows the heated plastic film drawn into the fissures by means of a vacuum.

FIGURE 3 is a sectional view of a third step in which a vacuum inducing means is positioned above the film in order to loosen it from the surface of the tile.

FIGURE 4 is a perspective view of a tile forming the subject of this invention, while

FIGURE 5 is a sectional view of the portion of the tile in FIGURE 4 along the line **5—5**.

The objects of this invention are, in general, accomplished by the application of a film to an acoustically vibratile plastic material or other type membrane to the surface of a fissured acoustical tile such that it extends substantially into the fissure voids. The film is then loosened from the surface but in contact therewith so that it will be acoustically transparent and function in the same manner as set forth in U.S. Patent Numbers 2,045,311 and 2,045,312. A preferred method of carrying out this invention, and which will be subsequently described in detail, is to draw a heat-softened thermoplastic sheet material into the fissures by means of a vacuum. It is then loosened from the surface of the tile after cooling by a vacuum acting thereabove. The membrane is adhesively attached to the tile along the edges prior to or preferably during the application of the vacuum.

In carrying out the preferred embodiment of this invention as shown in the drawing, a fissured acoustical tile **1**, such as of the mineral fiber type, and containing the fissures **2** formed when the surface of a baked sheetlike cast consisting primarily of nodules of mineral wool fiber bonded with a starch gel, is sanded, is placed upon the bed **3** over the vacuum chamber **4** with the ports **5** extending from the chamber to the surface of the bed. A thermoplastic sheet **6**, which can be 2 mil vinyl chloride, and of a suitable width is pulled from a roll or other source, not shown, over the lower clamp ring **7** while it is in its upper position, shown dotted, substantially coplanar to the surface of the tile. The upper clamp ring **8** is lowered from the dotted position onto the plastic sheet above the lower clamp ring forcing it downwardly against the springs **9** until the plastic is firmly clamped in place. In order to be assured that there is a firm grasping of the plastic by the clamps it is advisable to have one contacting surface of the clamps, i.e. the lower, coated with a gritty material, not shown, and the other surface, i.e. the upper, of a resilient material **10**, such as rubber. The

heating member **11**, which can be mounted upon a suitable track is then drawn over the plastic. This member is composed of a series of electric heaters which are adjusted to give sufficient heat by radiation to soften the plastic. When the plastic has softened sufficiently, usually after only a few seconds, the plastic and clamping ring assembly are lowered so that the plastic is drawn tautly over the face of the tile and the overhanging portion of the upper ring forces the plastic against the bed of the vacuum chamber, hermetically sealing it therewith. The vacuum in the chamber **4** from the line **12**, acting through the ports **5**, draws the softened sheet into the surface of the tile and along the edges, see FIGURE 2. The edges have been previously coated with a suitable heat activated adhesive. The heating member is then withdrawn. Each tile is preferably previously heated to a temperature 250° F. for about 10 minutes. This prepares the edge adhesive, if it is an emulsion requiring drying, and dries the tile. The tile is cooled to about 110° F. before the film is applied.

After the formed plastic sheet has cooled, the top vacuum platen **13** is lowered upon the face of the tile such that the gasket **14** forms a seal with the outer face of the tile. A vacuum is applied from the line **12** and the chamber **14** through the openings **15** to the plastic face which is thereby loosened from the tile, see FIGURE 3. If there is trouble with sticking of the plastic which sometimes is the case, especially if the surface of the tile has been previously coated, then a parting material such as powdered talc can be dusted over the tile prior to the application of the plastic. The top vacuum platen is moved upwardly to the position shown in FIGURES 1 and 2, the top clamping ring is moved to the position shown dotted in FIGURE 1, the bottom clamping ring is forced upwardly by the spring to the dotted position **7** also shown in FIGURE 1. After the tile has been removed, the apparatus is now ready for a repetition of the cycle.

After the tile has been removed from the forming apparatus, the edges are trimmed, and if desired, a rabbet is milled in along the edges for the insertion of a metal spline needed for erection of the tile. However, this can best be placed into the edges of the tile before the plastic is applied. The plastic need not extend beyond the rabbet unless a completely sealed tile is required, in which case the plastic can extend in the rabbet or groove as well.

Inasmuch as the positioning of the heating member, movement of the plastic and clamping rings, vacuum treatments and the withdrawal of the heating member only involve seconds, it is preferred to carry these operations out mechanically and automatically, using suitable timing means. It is within the scope of this invention to have the lower vacuum chamber raised after the plastic film has been clamped into position rather than the clamped plastic lowered such as described.

A wide range of membranes can be used; however, thermoplastic plastic films which are heat softenable in which state they can be stretched are preferred; they can be either calendered, extruded or cast. The film must be acoustically vibratable when cooled. It is possible as an alternative to extrude the plastic over the tile. Certain additives can be introduced during the preparation of the plastic so as to improve their suitability for the purpose, i.e., to increase their heat stability, extend the temperature range of the softened state and to improve the properties and appearance when in place. Such are within the skill of the art. Various thicknesses can be used such as from ¼ mil to 5 mils or more; good results have been obtained with a thickness of 2 mils. The plastic can be clear, coated, pigmented, flat or embossed. Each type of plastic, thickness and surface treatment requires it own heating time to reach its proper degree of forming plasticity.

TABLE I.—SOUND ABSORPTION VALUES FOR VARIOUS PLASTIC FACE FISSURED ACOUSTICAL TILE

Plastic Film Used	Gauge, in.	Forming Cycle		Absorption Coefficients at Frequencies Shown					
		Film Surface Temp., °F.	Heating Time, sec.	250	500	1,000	1,900	Total	NRC
Vinyl chloride homopolymer and methyl methacrylate polymer: calendered; rigid; opaque; white.	0.002	275–325	4	.540 (.175) .352	.735 (.040) .530	.852 (.040) .740	.800 (.325) .825	2.987 (.580) 2.447	.747 (.145) .612
Vinyl chloride-vinyl acetate copolymer: cast; rigid.[1]	0.001	225–275	3	.540 (.155) .430	.735 (.040) .500	.827 (.040) .723	.815 (.040) .760	2.917 (.275) 2.473	.729 (.068) .618
Same	0.001	225–275	3	.545 (.155) .425	.735 (.040) .590	.852 (.120) .725	.831 (.040) .795	2.963 (.355) 2.535	.740 (.075) .634
Highly plasticized, clear vinyl chloride-vinyl acetate copolymer: calendered.	0.0005	225–275	3	.554 (.185) .430	.748 (.040) .530	.876 (.040) .685	.855 (.040) .830	3.033 (.305) 2.475	.758 (.075) .618
Same [1]	0.0005	225–275	3	.554 (.080) .465	.748 (.040) .585	.845 (.040) .660	.825 (.040) .785	2.972 (.200) 2.495	.743 (.050) .623
Vinyl chloride polymer: opaque; white	0.002	275–325	4	.558 (.175) .472	.755 (.312) .650	.845 (.505) .780	.845 (.735) .815	3.003 (1.727) 2.717	.750 (.432) .679
Cellulose acetate-butyrate copolymer: clear; transparent.	0.005	300–350	6½	.548 (.040) .315	.737 (.040) .585	.865 (.240) .785	.845 (.430) .815	2.995 (.750) 2.500	.748 (.188) .625
Polyethylene [1]: extruded	0.003	300–350	[2] 10	.545 (.448) .490	.750 (.370) .092	.835 (.310) .780	.827 (.390) .770	2.957 (1.518) 2.732	.739 (.379) .683
Cellulose acetate-butyrate: clear; transparent [1]	0.0015	275–325	4	.548 Nonreleased plastic on face of tile not tested .232	.758 .395	.852 .695	.850 .735	3.008 2.057	.752 .514
Vinyl chloride polymer-rigid: extruded; clear [1]	0.005	300–350	6½	.548 Nonreleased plastic on face of tile not tested .305	.749 .405	.835 .600	.858 .775	2.990 2.085	.747 .521

[1] The surface of the tile was previously dusted with talc before applying the plastic film.
[2] The vacuum was applied for 5 sec.; all other for 3 sec.

NOTE.—Sound absorption values in parentheses are after the film has been applied but before loosening. Those immediately following are after loosening. Those immediately preceding are before applying the film. Discrepancies in values between coefficients of similar type tile are due to variations in tile surface and accuracy of testing apparatus.

Table I, above forming a part of the description of this invention sets forth examples of fissured mineral fiber acoustical tile which have been surface treated with various types and thicknesses of plastics. The heating time and temperature required to give the proper softening of the plastic is shown for a heating member made from Calrods placed side by side and which generates sufficient heat to give a temperature of from 100 to 400° F. upon the surface of the plastic. The exact temperature is between the range shown as determined by the use of Tempil Stiks, manufactured by the Claud J. Gordon Co., Chicago, Ill. The longer the exposure time the higher the temperature. Table I also gives the sound absorption values for the various frequencies shown as well as the NRC, i.e. the noise reduction coefficient. These values are given for each tile before the plastic has been applied and before and after the loosening of the plastic membranes from the face of the tile. These values were all obtained by means of the impedance tube method such as described in Standards No. 384–58 of the American Society for Testing Materials (ASTM) entitled "Impedance and Absorption of Acoustical Materials by the Tube Method." All tile were conditioned at a temperature of 77° F. and 50% relative humidity overnight. Each tile had an aluminum foil backing and was 12" x 12" x ¾" thick. The surface was coated with a casein type primer and a polyvinyl acetate finish coat. The sound absorption was not materially changed by the coating. The film was loosened from the tile by means of suction applied to various parts of the film surface. The film was pushed back into the fissures, however, the contact has been broken so that the film is free to vibrate and hence is rendered acoustically transparent. Note the unexpected increase in sound absorption value after the film has been loosened from the face of the tile. It approaches that of the original tile. Although the value is somewhat lower, the great improvement in washability, appearance and sanitation more than compensates for the lower NRC value. These tile can be used in kitchens, hospitals, and other locations where it is important for the surface to be kept clean such as by washing, etc.

TABLE II.—SOUND ABSORPTION COEFFICIENTS OF PLASTIC FACE FISSURED ACOUSTICAL TILE UNDER VARIOUS CONDITIONS

Type of Film	Condition of Plastic on Face	Sound Absorption Coefficients					
		250	500	1,000	1,900	Total	NRC
None	None (Bare Tile)	.540	.710	.780	.815	2.845	.711
Vinyl chloride homopolymer and methyl methacrylate polymer: calendered; rigid; opaque; white; .002".	Across face not in fissures	.445	.635	.765	.895	2.740	.685
	Across face in fissures	.295	.240	.220	.300	1.055	.264
	Same, released	.435	.575	.690	.795	2.495	.624
Vinyl chloride polymer: rigid; extruded; clear; .005".	Across face not in fissures	.330	.460	.640	.850	2.280	.570
	Across face in fissures	.420	.375	.345	.365	1.505	.376
	Same, released	.300	.465	.580	.670	2.075	.519

A further embodiment of this invention is set forth in Table II, above. In this table a fissured mineral fiber acoustical tile without any aluminum foil upon the back or a painted surface but with the surface dusted with talc was first tested for sound absorption. A film of the .002" vinyl chloride-acrylic plastic referred to in the table was then drawn taut across the tile and tested for sound absorption. Another test was made with the plastic drawn into the fissures followed by a final test with the plastic released from but contacting the surface. This film was removed and the .005" vinyl chloride film also referred to in Table II was stretched across the tile. The entire procedure was repeated. The same tile was used in all of the tests shown. Note that when the plastic face is placed across the tile there is a relatively low loss in acoustical value as compared with the film drawn into the fissures. However, this is substantially restored when the film is released. A thicker plastic usually has a lower sound absorption value for the same conditions.

A wide range of adhesives can be used to adhere the plastic to the edges of the tile such as, for example, those of the heat activated types. In the preferred examples set forth above, an adhesive known as Milligan 2858 was used. This adhesive is of the water emulsion type and is made from a mixture of the following emulsions: 225 parts Minnesota Mining and Manufacturing EC971, and an oil resin elastomer, 90 parts of polyvinyl acetate copolymer (Dewey and Almy Chemical Co. Everflex B) and 135 parts of polyacrylate polymer (B. F. Goodrich Co. Hycar 2601). This mixture of emulsion is added along the edges and dries, usually during the preheating of the tile prior to the application of the plastic. It is activated by the heat from the heating member during the softening of the plastic membrane prior to vacuum forming. The plastic film or sheet **6** is drawn to the edges of the tile when the vacuum is applied and adhered by the adhesive layer **16**, see FIGURES 4 and 5. Various other types of adhesives can be used for this purpose, which are well known to those skilled in the art.

It is not essential that the plastic extend entirely into the fissures, as the fissure design will be revealed when the plastic is only a substantial distance therein. This is especially true in the case of a clear type plastic, as the fissures and other pleasing irregularities on the surface of the tile are revealed therethrough. A pleasing fissure design is also formed by a coated plastic. It is within the scope of this application and sometimes preferred to darken the recessed areas to accentuate the fissures. This is especially desirable when a non-transparent film is used.

In order to emphasize the importance of the film being loosened from the surface of the tile, and therefore acoustically transparent, a space is shown between the plastic and the tile surface in FIGURE 5. However, this space is hardly noticeable in the actual tile. Although the membrane is loosened from the surface of the tile, it still is in surface contact therewith; this along with the strengthening and keying of the plastic due to the contour formed by the vacuum forming, results in practically no sagging. This freedom from sagging of the membrane, though adhered only along the edges, is considered an important part of this invention.

While the fissured mineral fiber acoustical tile is used as a preferred example, it is to be understood that the scope of the invention is not to be limited thereto, but to any type of cavity acoustical tile regardless of shape which is to be protected and rendered more cleanable by the application of a plastic film or other membrane thereover in such a manner that the cavities are revealed upon the surface. Thus the term "fissure" or "fissured" is to connote such cavities as well.

While a foil backed, fissured, mineral fiber, acoustical tile is the tile of choice and used in preparing the data for Table I, various other types of impervious or semi-impervious sheetlike members or plastic films may also be used upon the back of the tile in place of the aluminum foil. The sheetlike member can also be adhered to the tile after it has been made either before or after the vacuum forming of the film upon the surface. The aluminum foil is added during the formation of the slab by casting the mixture of noduled mineral wool and starch gel thereon. While the aluminum foil is substantially impervious to the passage of air during the vacuum formation, it was discovered that there is sufficient infiltration along the sides of the tile to enable the vacuum to draw the membrane into the fissures of the tile.

Such tile are a marked improvement in the art as they are substantially completely sealed from moisture and dirt. This not only contributes to the cleanability but also

improves the resistance to sag as the amount of moisture reaching the interior of the tile is substantially reduced. The presence of moisture contributes to the sagging of the tile itself. Thus it is an important part of this invention to prepare a completely enclosed tile and still retain the pleasing fissured effect as the top membrane **6** can extend around the edges to a point where it will meet or preferably overlap the water vapor impervious sheetlike member **17**. This will completely seal the tile. Such extension of these enclosures have been added in FIGURE 5. The corners can either be cut and the edges of the enclosures butted together or they can overlap.

While in the above example, a vacuum was used to draw the plastic into the fissures, and is preferred, various other methods may be used to accomplish the same purpose, such as the use of air to force the plastic into the fissures, or mechanical means. In addition, other methods of loosening the plastic from the face of the tile can be used such as air pressure acting from the back face of the tile against the film. In this case it is better to not have an impervious sheetlike member on the back surface of the tile.

While it is preferred to use the apparatus set forth above and shown in FIGURES 1, 2 and 3, it is not the intention to limit the scope of this invention to such an embodiment, for various modifications can be made in the apparatus and process for manufacturing a plastic-faced, fissured, acoustical tile without departing from the scope of this invention. For example, while only one tile is shown in the figures it is possible to place a number of tile in adjoining relationship and apply the plastic to all of them at one time. In this case a space should be left between the tile so that the plastic can be drawn against the edges by the vacuum. Also, additional ports are needed to facilitate such action.

It is also possible to use an assembly line method of manufacture in which the tile are moved to various positions to carry out the various steps such for example:

(1) applying the edge glue such as an aqueous emulsion,
(2) drying the glue and conditioning the tile as by drying to remove extraneous moisture which may be trapped within the tile if completely enclosed,
(3) applying a release material, such as powdered talc, to the surface of the tile, if needed. This can be applied earlier,
(4) applying the plastic over the surface of the tile,
(5) softening the plastic by heat,
(6) drawing the plastic tautly across the surface of said tile,
(7) drawing the softened plastic into the fissures and around the edges of the tile such as by a vacuum,
(8) cooling the plastic,
(9) loosening the plastic from the body of the tile such as by a vacuum and thereby rendering it in contact but acoustically transparent relationship with the surface of the tile, and
(10) trimming the plastic along the edges of the tile.

Besides the fissured mineral fiber acoustical tile used as a preferred example it is within the scope of this invention to use other types of tile which have cavities formed within their surface such for example as those made from wood fibers in which the cavities are molded into the surface while the tile is wet, or drilled, milled or sawn therein when dry.

As mentioned above, a wide range range of membranes can be used; it is important, however, that it be thin and acoustically vibratile and that it loosely or resiliently contact the surface of the tile so that it is substantially acoustically transparent with respect thereto. By a thin and acoustically vibratile film is meant such a film which is acoustically transparent in nature so as to transmit the sound waves impinging thereagainst to the sound absorbency tile over which it has been applied as taught by Patent Numbers 2,045,311 and 2,045,312. The film of course must also meet the established standards of cleanability, appearance, and formability required for proper commercial utility.

Various other modifications can be made in the method of fabricating, types of films used, adhesives and modifications of the edges and back of the tile for certain specific purposes and still be within the scope of this invention which is only limited by the forthcoming claims.

I claim:

1. An acoustical board of bonded mineral fibers having a vibratile film of plastic composition disposed over and unattached to the face of the board and having edge portions stretched smoothly down the side edges and smoothly around the corners of the board, said edge portions of the film being adhered directly to the side edges of the board, said film having an irregularly configured formation on the face of the board with such formation complying with irregularities of and peculiar to the underlying fibrous surface.

2. An improved, fissured, acoustical tile substantially completely encased within a substantially water vapor-impervious enclosure comprising an acoustical tile having fissures upon its face surface; a thin, acoustically-vibratile, water vapor-impervious membrane extended across the face of said tile and substantially into the cavities of said fissures and along the edges of said tile; said membrane being in acoustically transparent relationship with the surface of said tile, and a water-impervious, sheet-like member extending across the back surface of said tile with the terminating edges thereof in at least close adjacent relationship with the terminating edges of said membrane.

3. The fissured acoustical tile of claim **2** in which said water-impervious, sheet-like member is made from aluminum.

4. A membrane-surfaced, fissured, acoustical tile covered on at least one fissured, major surface with a thin, acoustically-vibratile and acoustically-transparent membrane extending substantially in the fissures of said tile and in nonadhesive contact with said surface.

5. The acoustical tile of claim **4** in which said tile is formed of mineral fibers.

6. The acoustical tile of claim **4** in which said tile is formed of wood fibers.

7. The acoustical tile of claim **4** in which said membrane has a thickness between about .25 and 5 mils.

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