March 23, 1965 K. W. SCHULZ ETAL 3,174,580

ACOUSTICAL TILE CONSTRUCTION

Filed April 28, 1961

FIG. 1

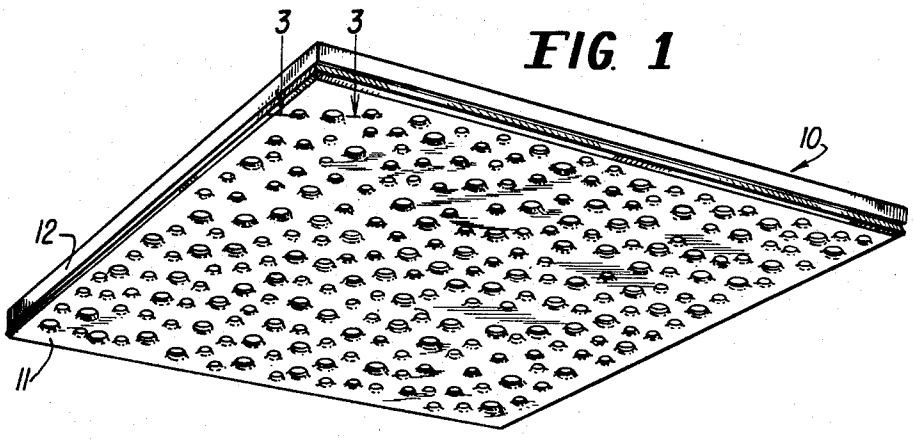


FIG. 2

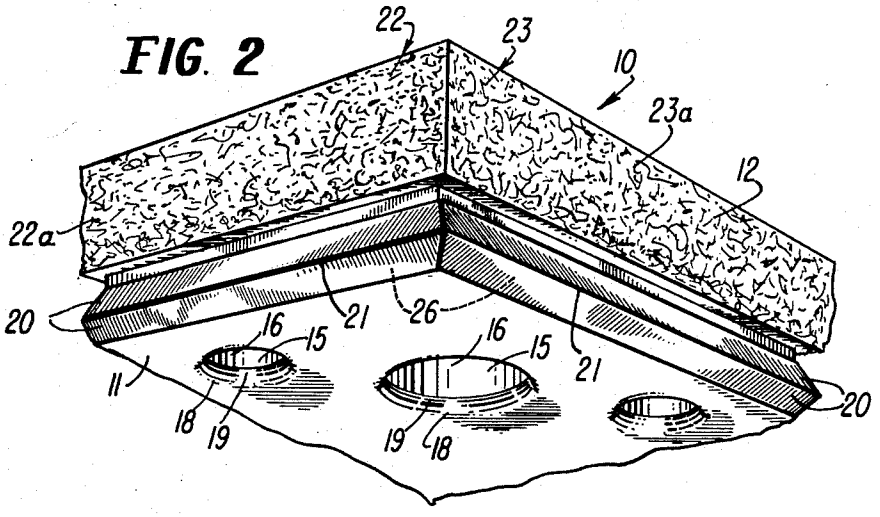
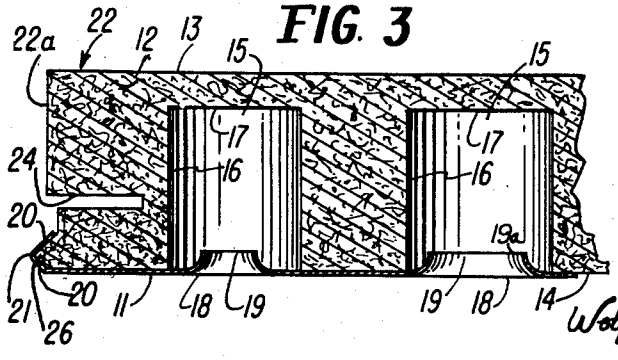


FIG. 3



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ACOUSTICAL TILE CONSTRUCTION

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This invention relates generally to acoustical tile and more particularly to acoustical tile having one surface provided with a pattern of sound receiving recesses.

It is an object of the present invention to provide a novel acoustical tile which because of its construction has a higher noise reduction coefficient than that of conventional acoustical tile. More particularly, it is an object to provide an acoustical tile which not only absorbs and thereby dampens sound vibrations, but also effectively traps within it a portion of the vibrations which strike it.

An ancillary object is to provide such an acoustical tile which readily permits sound vibrations to enter its sound receiving recesses and then effectively prevents escape of the vibrations out of the recesses.

It is an additional object to provide an acoustical tile having a surface which due to its novel construction is both stronger and more atttractive than the facing of ordinary acoustical tile.

Yet another object is to provide a novel acoustical tile having the above characteristics which is inexpensive and economical to manufacture, easy to install and which may be readily and conveniently cleaned or painted.

Other objects and advantages of the invention will become apparent upon reading the attached detailed description and upon reference to the drawings in which:

FIGURE 1 is a perspective view showing an illustrative acoustical tile incorporating the features of the present invention;

FIG. 2 is an enlarged fragmentary perspective view of a corner portion of the tile; and

FIG. 3 is an enlarged fragmentary cross-sectional view taken along the line 3—3 in FIG. 1.

While the invention will be described in connection with a preferred embodiment, it will be understood that we do not intend to limit the invention to that embodiment, but on the contrary, intend to cover alternatives, modifications and equivalents as may be included within the spirit and scope of the invention as defined by the appended claims.

Turning now to the drawings, there is shown an acoustical tile **10** incorporating the features of the present invention. In the preferred embodiment, the tile **10** comprises a substantially flat, relatively thin facing sheet **11** and a thick, substantially rigid backing board **12**. It will be understood that the backing board **12** is made of any suitable fibrous or composition material commonly employed in the fabrication of conventional acoustical tiles. The light-weight, porous nature of such materials has made them particularly well suited for acoustical end-uses since their sound absorbing properties greatly exceed those of non-porous materials.

As shown (see especially FIG. 3), the backing board **12** has a rear surface **13** and a front surface or face **14**. To lend sound absorbing efficiency to the backing board **12** it is provided with a plurality of sound absorbing recesses or openings **15** which extend from the face **14** substantially into but not entirely through the thickness of the board. In this instance the recesses **15** are substantially circular in cross-section and are each defined by a circumferential wall **16** terminated by a circular base **17**. As is well know such recesses function to permit ready dispersion throughout the board of sound vibrations which strike its front surface.

Such a backing board **12** may be prepared, for example, by cutting a suitable insulating type fiber board to the desired size, e.g. 12" x 12" x ¾", and drilling its front face **14** using a single or multiple spindle drill to provide the plurality of recesses **15** extending from the front face **14** of the tile toward its rear surface. An exemplary pattern of recesses in such a tile would be 3/16" diameter holes drilled on ½" centers to form 22 rows of 22 holes each or 484 holes in each tile. Alternatively, an irregular pattern of holes of uniform or varying diameters may be employed if desired.

The facing sheet **11** is preferably formed of relatively thin metal, rigid plastic sheeting or the like, and is provided with a plurality of sound receiving openings or holes **18** which openings are of the same shape as and arranged in the same pattern as that chosen for the recesses **15** provided in the backing board **12**.

As will be seen the facing sheet **11** is juxtaposed in relation to the backing board **12** such that the centers of the openings **18** register with the centers of the recesses **15**. The sheet **11** and backing board **12** may be secured together in any suitable manner, for example by using a suitable adhesive. As shown the edges of the facing sheet **11** are flashed around the peripheral edges of the backing board. Preferably a marginal edge portion **20** of the facing sheet **11** is folded or crimped rearwardly around the edge of the backing board **12**, the shape of the board edge and edge portion **20** being such as to define an apex **21** as viewed in section which forms a line of juncture between adjacent tiles when they are assembled together.

A peripheral groove **24** is preferably provided around the sides of the board and positioned rearwardly of the edge portion **20** for receiving the flange of an I-bar or T-bar (not shown) attached to the ceiling or wall to which the tile is to be secured, or for receiving a suitable spline (also not shown) which facilitates alignment of and strengthens adjacent tiles. In order to accommodate the web of such an I-bar or T-bar the rearmost portions **22***a*, **23***a* of the cojoining sides **22**, **23** are formed so as not to extend outwardly as far as the plane of the line of juncture between tiles defined by the apex **21**. When the illustrative acoustical tiles are so installed the grooves **24** of adjacent tiles accommodate the flange of the beam passing between them with the web of the beam being received between the adjacent side portions **22***a*, **23***a* of the tiles.

The bevelled corner **26** of the backing board **12** peripherally surrounding the face **14** improves the interfit of adjacent tiles as well as their appearance. In this way the facing sheet **11** is made to conform intimately to the outer surface **14** of the backing board **12**, thereby providing a neat and attractive acoustical tile.

The sound absorbing efficiency of acoustical tile, of course, varies depending on a number of factors including its thickness, porosity, and the depth, diameter and pattern of the recesses **15**. The sound absorbing efficiency of a given tile is evaluated by those skilled in this art by a standard test which determines the noise reduction coefficient (NRC) of the material. This test consists of measuring the reverberation room sound absorption efficiency of the tile at a series of fixed sound frequencies, i.e. at 250, 500, 1,000 and 2,000 cycles per second. The arithmetic average of the reverberation room sound absorption coefficients at each frequency becomes the overall noise reduction coefficient. The average noise reduction coefficient of conventional acoustical tile often varies in the range of .40 to .60. It is understood that the higher NRC value designates the better sound insulator.

In accordance with the present invention, the sound

absorbing efficiency of the acoustical tile **10** is greatly improved as compared with conventional tiles by making the face sheet openings **18** smaller in diameter than the diameters of the recesses **15** with which they register. Due to this construction the NRC of the instant acoustical tile is much higher than has been feasible in the past.

As will be seen from the drawings, a portion of sound vibrations which strike the front face of the tile **10** will pass through the sound receiving openings **18** in the facing sheet **11** and enter the sound absorbing recesses **15** of the board **12**. Upon so entering each of the board recesses **15**, the sound vibrations strike the walls **16** and base **17** and become in substantial part absorbed by the porous mass of the backing board **12**. The unabsorbed portion of the vibrations are reflected from these respective surfaces but, importantly, the majority of these vibrations cannot escape from the recesses **15** due to the restriction caused by the smaller diameter of the facing sheet openings **18** in relation to that of the recesses. It will thus be appreciated that most of the initially unabsorbed portion of the entering sound vibrations are effectively trapped within the sound absorbing recesses **15** and prevented from escaping out through the openings **18**. The so trapped sound vibrations are subsequently dispersed into and absorbed by the board proper thereby enhancing the noise reduction efficiency of the tile.

It has been found, moreover, that maximum sound absorbing efficiency results when the ratio of the recess (**15**) diameter to the face sheet opening (**18**) diameter is in the range of about 1.25 to about 3.33. In such instances the acoustical tile of the present invention is found to have an NRC of as high as 0.75 compared with the usual range of 0.40–0.60 for ordinary acoustical tile.

Table I below sets forth test results which illustrate the improved NRC obtained for acoustical tile constructed in accordance with the present invention, using different ratios of diameters of the recesses **15** to the openings **18**.

Table I

Sample No.	Recess (15) Diameter	Opening (18) Diameter	Ratio	NRC
1	4/32	4/32	1:1	.60
2	5/32	4/32	1.25:1	.66
3	6/32	4/32	1.50:1	.72
4	8/32	4/32	2.00:1	.75
5	10/32	4/32	2.50:1	.73
6	3/32	3/32	1:1	.53
7	5/32	3/32	1.67:1	.67
8	6/32	3/32	2.00:1	.74
9	8/32	3/32	2.67:1	.745
10	10/32	3/32	3.33:1	.74

The backing board **12** used in all of the instant test tiles was a one inch thick commercially available product comprising a major proportion of expanded perlite, some vegetable fibers and a minor proportion of binder. The facing sheets **11** employed in all test tiles were formed of thin aluminum sheeting, and the recesses **15** and openings **18** in registry therewith in all test tiles were spaced on one-half inch centers.

As will be observed from the data in Table I the 1.25 ratio of the two diameters results in an increased NRC over that obtained using a 1.00 ratio, and a ratio of 2.00 or greater provides an even higher NRC. Although no tests were conducted for ratios above 3.33 it is to be expected that such ratios would result in a further increase in NRC. As a practical matter, however, it will be appreciated that as the ratio of diameters is increased, either the openings **18** in the facing sheet **11** become unduly small, thus undesirably restricting the proportion of impinging sound vibrations entering them, or fewer recesses **15** may be provided per square unit of backing board **12**. It therefore is desirable to maintain the ratio of recess (**15**) diameter to opening (**18**) diameter within approximately the above mentioned range, i.e. from about 1.25 to about 3.33.

For the purpose of increasing the sound trapping effect and also to improve the strength and appearance of the facing sheet **11**, the portions of the facing sheet **11** marginal to the openings **18** are preferably formed with an internally extending circumferential lip **19** (see FIG. 3). It is understood that the lip **19** may be formed by any convenient method, such as by first drilling a plurality of holes in the sheet **11** and then pressing enlarged tapered punches through the holes to stretch and curve inwardly the peripheral stock. In this way each of the openings **18** is provided with a circumferentially tapered shoulder having a smoothly rounded contour which merges into the plane of the facing sheet **11**. The lip **19** thereby in cooperation with the recess wall **16** forms a captive corner which increases the proportion of sound vibrations trapped within the recess **15**. Such trapped vibrations are of course eventually absorbed by the board **12**. The rearwardly extending lip **19** serves, moreover, to strengthen the relatively thin facing sheet **11** by giving it a corrugated-like or dimpled construction. The rounded contours of the openings **18** also impart to the face of the tile a considerably enhanced appearance (see FIG. 1).

It is understood that where reference is made herein to the diameter of the openings **18**, the diameter meant is the inside diameter at the rearmost end **19***a* of the lip **19** (see FIG. 3). Of course it may under some circumstances be preferable to form the facing sheet **11** as simply a punched or drilled flat sheet, i.e. without provision of the circumferential lips **19** surrounding the sheet openings **18**, in which case the diameter of the patterned openings will be uniform throughout the depth of the openings.

The acoustical tile of the present invention also incorporates many additional advantageous features. For example the instant tile construction obviates many disadvantages considered to be inherent in fiber or composition type acoustical boards. Such disadvantages include the tendency of fibre boards to readily absorb moisture when being cleaned or painted and their lack of fire resistance (thereby requiring use restrictions under many building codes). In addition the fibrous make-up of such tiles does not permit clean, well defiined recesses to be formed in them (particularly where twist drills are used for this operation), i.e. stray loose fibers frequently extend into the recesses from the surrounding board leaving the edges of the recesses frayed and increasing the tendency of paint to bridge over and entirely or partially clog the recesses. All of these disadvantages are overcome by the instant tile construction which provides an impervious facing **11** making possible ready cleaning or painting of the tile without absorption of liquid into the porous backing board, as well as providing well defined openings **18** which reduce the tendency of paint to bridge over and clog the board recesses **15**. The metal or plastic facing **11** also increases the fire resistance of the tile and makes it available for more applications.

In the illustrated embodiment, the recesses **15** and openings **18** have been shown to be of various sizes and arranged in a random pattern across the face of the tile **10** (see FIG. 1), It is to be understood, of course, that other patterns, sizes and shapes of recesses and openings may be employed if desired. For example another arrangement falling within the scope of the present invention would be one in which the recesses and openings are uniformly sized and spaced.

We claim as our invention:

1. An acoustical tile for absorbing sound vibrations comprising, in combination, a substantially rigid backing member formed of a sound absorbing material of a relatively light weight porous nature, said backing member defining a pattern of spaced cylindrical recesses extending substantially into said backing member and terminated by a base portion formed internally of said backing member for dispersing sound vibrations within the backing member, a facing sheet having a series of openings distributed over its face in a pattern corresponding to that of said

recesses, said facing sheet overlying and in contact with said backing member such that said openings are in registry with said recesses, and said facing sheet having portions thereof marginal to said openings smoothly rounded out of the plane of the facing sheet and into the recesses of the backing member to thereby form an inturned lip around each opening, each of said inturned lips having a smaller transverse dimension than said recesses cooperating therewith to form a captive corner behind said facing sheet to trap sound vibrations within said recesses.

2. An acoustical tile as defined in claim 1 wherein said openings are circular and said inturned lips are circumferentially disposed and the ratio of the diameters of said cylindrical recesses to the diameters of said openings at the innermost end of said lips is in the range of from about 1.25 to about 3.33.

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