Sept. 15, 1953 J. MAZER 2,652,126

SOUND-ABSORBING STRUCTURE

Filed Dec. 24, 1949

Fig. 1.

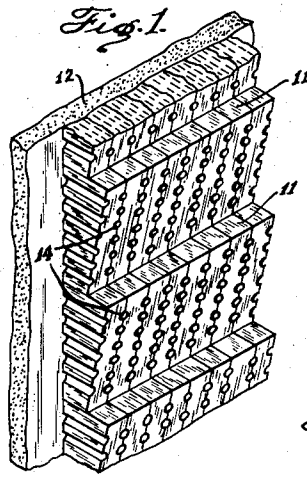


Fig. 2.

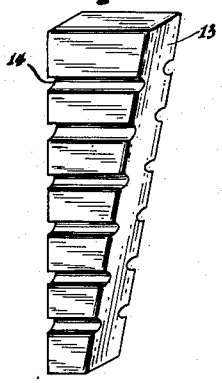


Fig. 3.

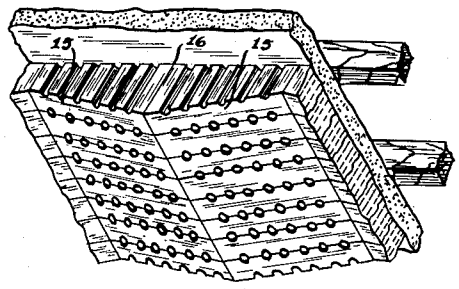


Fig. 6.



Fig. 4.

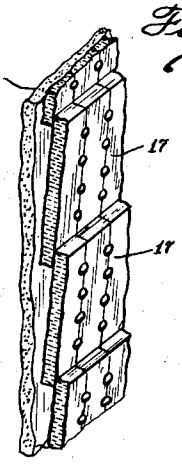


Fig. 5.

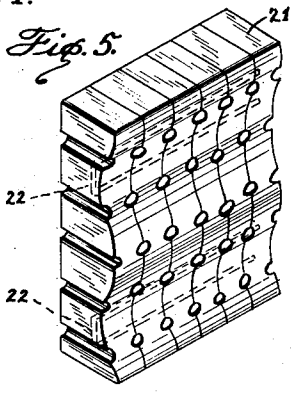


Fig. 7.

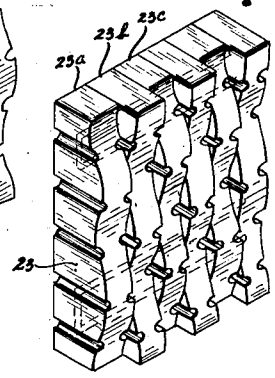


Fig. 10.

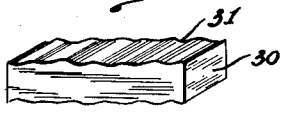


Fig. 8.

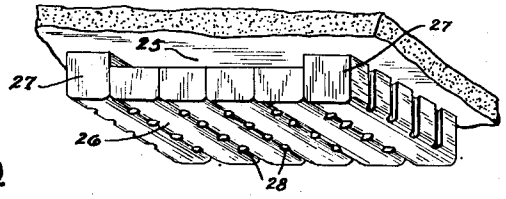


Fig. 11.

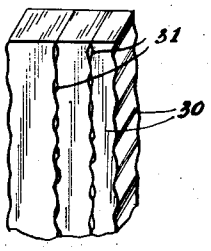
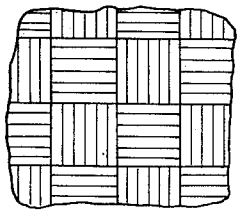


Fig. 9.



INVENTOR.
JACOB MAZER
BY Archworth Martin
Attorney

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SOUND-ABSORBING STRUCTURE

Jacob Mazer, Germantown, Pa.

Application December 24, 1949, Serial No. 134,923

3 Claims. (Cl. 181—33)

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This invention relates to sound-absorbing structures of the same general type as that shown in my application Serial No. 91,955, filed May 7, 1949, the present application being directed primarily to various arrangements of sound-absorbing units not disclosed in the said application.

In placing sound-absorbing materials in rooms, against the ceiling or walls, attention has been directed primarily to the matter of securing sound-absorbing or sound-quieting effects, with insufficient consideration of the distribution of sound that is not absorbed. The result has been that even though the reverberation period has been much reduced in a given room or enclosure and the acoustical effect materially improved thereby, in many cases, still greater acoustical improvement can be effected by controlled distribution or diffusion of the deflected sound. Even where there is substantial sound absorption, it is not unusual for one-half or more of the sound to be deflected from the sound-absorbing units and from the other surfaces of a room, and even more than one-half of the sounds of low frequencies are deflected, thus producing disturbing acoustical results.

Owing to this lack of controlled deflection, particularly from the higher-sound absorbing surfaces, parts of the audience such as that directly in front of the speaker or other sound source will hear the sounds with greater intensity than is necessary or comfortable, while those parts of the audience to the rear or at the sides of the room, will receive the sound with insufficient intensity, for comfort or clarity.

My invention has for its object the provision of sound-absorbing structures or units that can readily be so arranged as to deflect and diffuse the unabsorbed sound to desired parts of a room, thus making for the more even distribution and intensity of the audible sound.

Some of the forms which my invention may take are shown in the accompanying drawing, wherein Figure 1 is a perspective view of a portion of a wall or ceiling equipped with my invention; Fig. 2 is an enlarged view of one of the strips or pieces employed in assembling the unit of Fig. 1; Fig. 3 is a perspective view of a portion of a wall or ceiling showing the modification of the structure of Fig. 1; Fig. 4 shows still another modification; Fig. 5 is a perspective view of a sound-absorbing unit having reflecting surfaces arranged on curved lines; Fig. 6 is an enlarged detailed view of one of the strip members of Fig. 5; Fig. 7 shows a modification of the structure of Fig. 5; Fig. 8 shows still another form of the invention; Fig. 9 is a schematic view showing a manner in which various units may be arranged,

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in assembled relationship, on a wall or ceiling; Fig. 10 shows another form of strip, and Fig. 11 shows a unit formed of such strips.

While the various units shown in the drawing show the units as being built up of strips and having grooves and holes therein of predetermined number, spacing, size and shape to increase sound absorption, as shown in my said application, it will be understood that various features of the invention and particularly the curved or angular disposition of the faces of the units is of advantage in the controlled deflection of sound waves even though the units were made in the form of large or small single-piece slabs or sheets of other types of sound-absorbing material.

Referring first to Figs. 1 and 2, I show a plurality of units 11 applied to a wall or ceiling 12 and each composed of strips 13 that may suitably be formed of fibrous material after the manner of well-known fiber boards or more loosely compacted fibrous strips, or of other porous material of desired density or compactness. The strips 13 of each unit 11 can be secured together by cementing or wiring as in Fig. 5 or can simply be cemented to the wall 12. As in my said application, the sides of the strips 13 are grooved, so that when they are assembled, there will be circular or other shaped holes 14 into which the sound waves may penetrate and will be absorbed or dissipated as explained at length in my said application wherein the fibrous strips are so assembled that sound waves which enter the holes will in part be absorbed by entrance between the opposed faces of the strips. The strips may, of course, be of various sizes. For example, a strip of Fig. 2 may be ½ inch in thickness, and from 1 inch to 3 inches in depth and almost any desired length. These units can be cemented or nailed to the wall or ceiling or even suspended out of contact with the wall or ceiling.

It will be seen that the sloping faces of the units 11 reflect sound waves at different angles than if the unit faces were parallel to the plane of the wall 12. For example, if the units are placed on the rear wall of a room, wherein the sound originates at the front of the room, the portions of the sound waves that impinge upon units and are not absorbed will be deflected in a generally downward direction toward the audience located in the rear parts of the room, with consequent better hearing. Somewhat the same effect will be produced if the units are placed on a ceiling or upper side walls. The slope of the faces would, of course, be disposed in such manner as to deflect sound waves either laterally

in the room or forwardly or rearwardly therein, at desired angles and in desired areas predetermined by proper study of the size and shape of the room, use of the room, and the materials of construction.

In Fig. 3, I show units **15** similar to the units **11**, but wherein the butt ends or thick ends of the units are placed in engagement with one another at **16**. This gives a wave-like effect whether the faces of the units are curved or have flat planes, and the units are effective in spreading the deflected sound waves, resulting in much better distribution thereof over the audience area than if the faces of the units were parallel to the wall or ceiling.

In Fig. 4, I show an arrangement whereby the units **17** may be of uniform thickness and still so arranged as to effect desired angular deflections, as distinguished from the deflections less widely distributed and of larger wave-front, such as occurs when the faces of the units are parallel to the wall or ceiling **18**. Here again, the units can be turned in various directions on a wall or ceiling, and the arrangement has the further feature of providing spaces between **18** and the units, resulting in increased sound absorption values, especially for the sounds of low frequencies.

Referring now to Figs. 5 and 6, I show strips **21** of the form disclosed in Fig. 4 of my prior application, with particular reference to the wave-line contour of the outer edges or faces of the strips. The deflecting and diffusing effect of the units of this character is similar to that of Fig. 3, wherein each unit has controlled deflection of sound waves in a plurality of directions. The strips of Fig. 5, as in the case of the other units, can be glued together or held together by wire lacing as at **22**.

In Fig. 7, I show a unit **23** which is composed of strips arranged similarly to those of Fig. 5, but wherein the convex and concave areas of each strip are staggered relative to the concave and convex areas of the adjacent strips. There is, therefore, not only the deflection of sound waves by the curved areas, but there is multiple deflection between the protuberant or convex areas of alternate strips. Thus convex surfaces of a strip **23***a* are disposed along side of the concave surfaces of a strip **23***b* and in opposed relation to the convex or protuberant surfaces of a strip **23***c*, and so forth across the unit. Sound waves are repeatedly deflected back and forth between these raised surfaces, thus increasing both the absorption and the diffusion of the sound.

In Fig. 8, I show another arrangement, wherein there is a space **25** behind the face of a sound-absorbing unit **26** that may suitably be made of strips secured together in unitary relation and wherein the marginal strips **27** are of greater depth than the other strips, so as to provide for the spacing at **25**. Holes **28** may lead into the space, but the space is acoustically effective with or without the holes.

Fig. 9 shows a mosiac-like arrangement into which various of the units may be placed not only to give a pleasing architectural effect, but also to deflect sound waves at an increased multitude of angles.

In Fig. 10, I show a form of strip **30** which differs from those shown in the various other figures, in that its sides that are perpendicular to the wall are of irregular contour, so that when the strips are assembled as shown in Fig. 11, there will be a number of apertures **31** of uneven shape that serve as sound-absorbing openings, it being understood, of course, that there will be sound dissipation or absorption between the opposed walls of these strips throughout substantially the entire length of the strips, even where the strips have some direct engagement with one another at areas between the openings **31**. Some of the depressions at **31** in one strip are not directly opposite to depressions in the other strip. A similar staggered arrangement could be made in the case of the smooth round holes or grooves of the other units, so that the one-half grooves in each strip would not necessarily be directly opposite to the half-grooves of the adjoining strips.

Referring further to the various advantages of having slabs of non-uniform thickness as in Figs. 1, 3, 5, 7 and 8, the thickness of a sound-absorbing unit, whether of the perforate or imperforate type, is of some consequence, because increasing the thickness of a unit, results in a general increase in its absorption capacity, particularly at the lower frequencies, such as 128 and 256. Generally, the ideal material would be one that has the same efficiency at all frequencies, but since this is not possible, I obtain a better average of absorption coefficients by providing slabs or units of different thickness at various of its areas. The stepped arrangement of Fig. 4 produces a general average effect somewhat similar to the use of slabs of non-uniform thickness.

As stated heretofore, the units can be made up in the form of single slabs instead of assembled strips and may be of various materials other than the fibrous materials referred to. Also, the sloping and curved surfaces are of utility aside from the inherent sound-absorbing capacity of the unit, since such surfaces will give controlled reflection of sound waves.

It will be understood that the term "wall" is used in a broad sense, and that it is contemplated the units shall be applied to walls, ceilings, columns, or even mounted in spaced relation to such surfaces.

I claim as my invention:

1. A sound-absorbing structure comprising slabs of fibrous sound-absorbing material, each formed of fibrous strips assembled in side-by-side abutting relation for the entry of sound waves between them and the strips having grooves that extend rearwardly from the faces of the slabs, along the opposing faces of the strips.

2. A sound-absorbing structure as recited in claim 1, wherein some of the strips extend rearwardly a lesser distance than adjacent strips.

3. A sound-absorbing structure as recited in claim 1, wherein some of the strips are of wave-like contour on their outer surfaces.

JACOB MAZER.

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