Feb. 25, 1958 W. L. HARTSFIELD 2,824,618

SOUND ABSORBING WALL PANELS

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Fig. 1

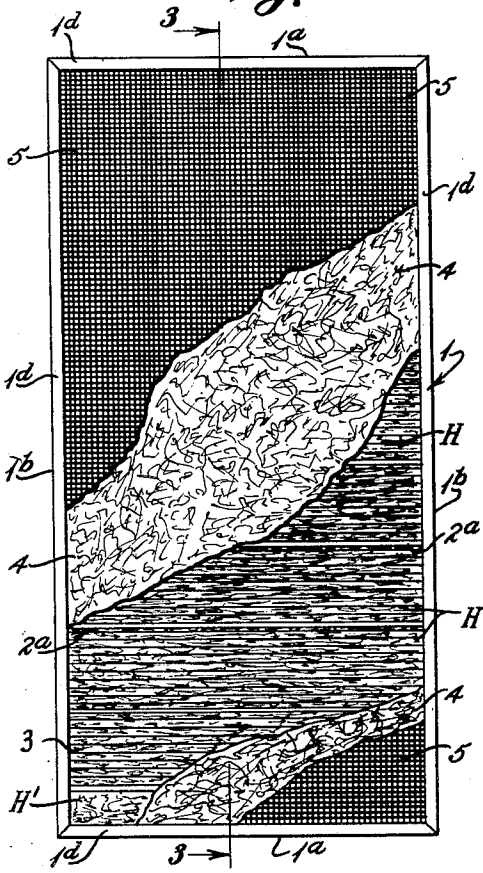


Fig. 2

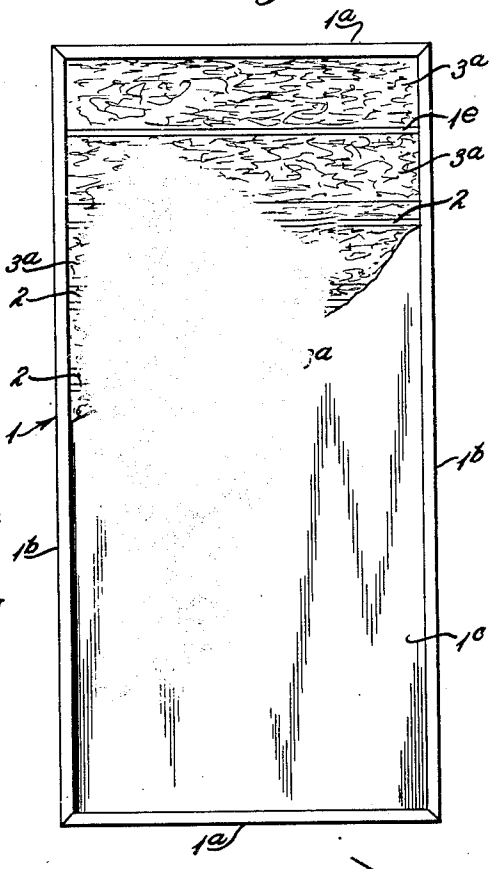
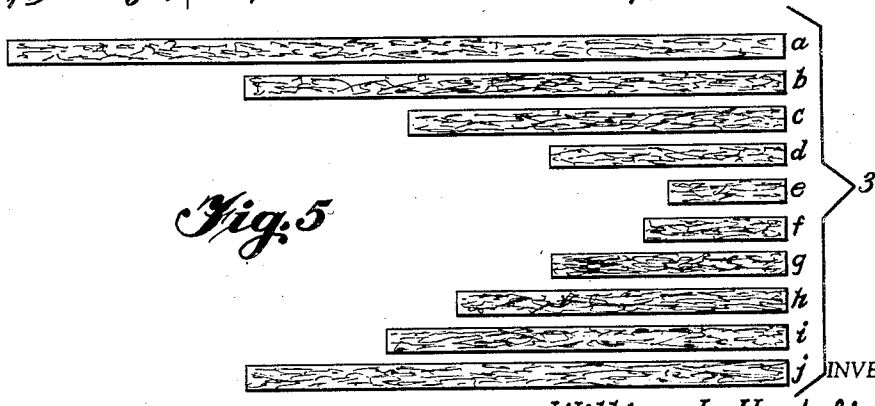


Fig. 5



INVENTOR

William L. Hartsfield

BY Alexander & Dowell

ATTORNEYS

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Fig. 3

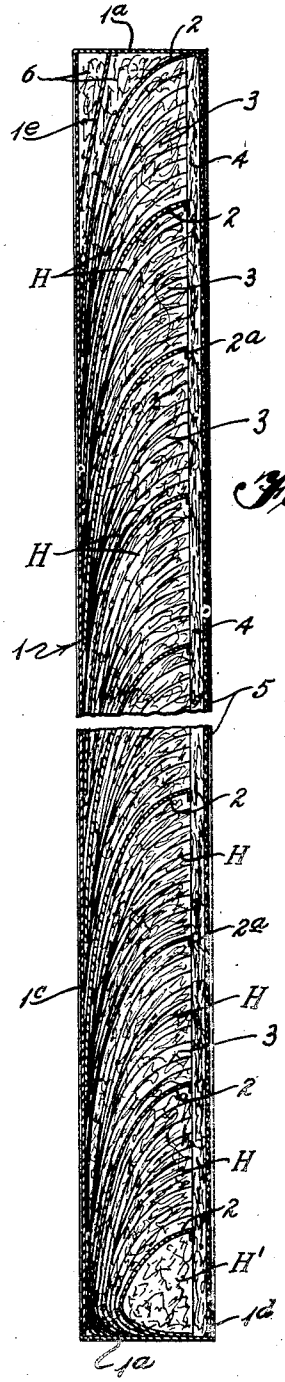
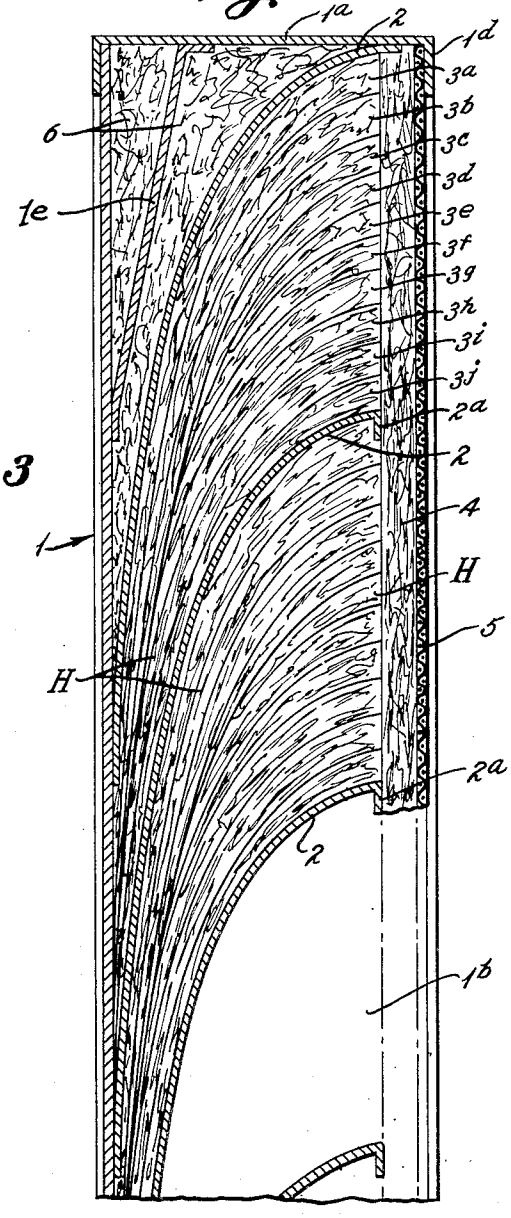


Fig. 4



INVENTOR

William L. Hartsfield

BY Alexander & Dowell

ATTORNEYS

Feb. 25, 1958 W. L. HARTSFIELD 2,824,618

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Fig. 6

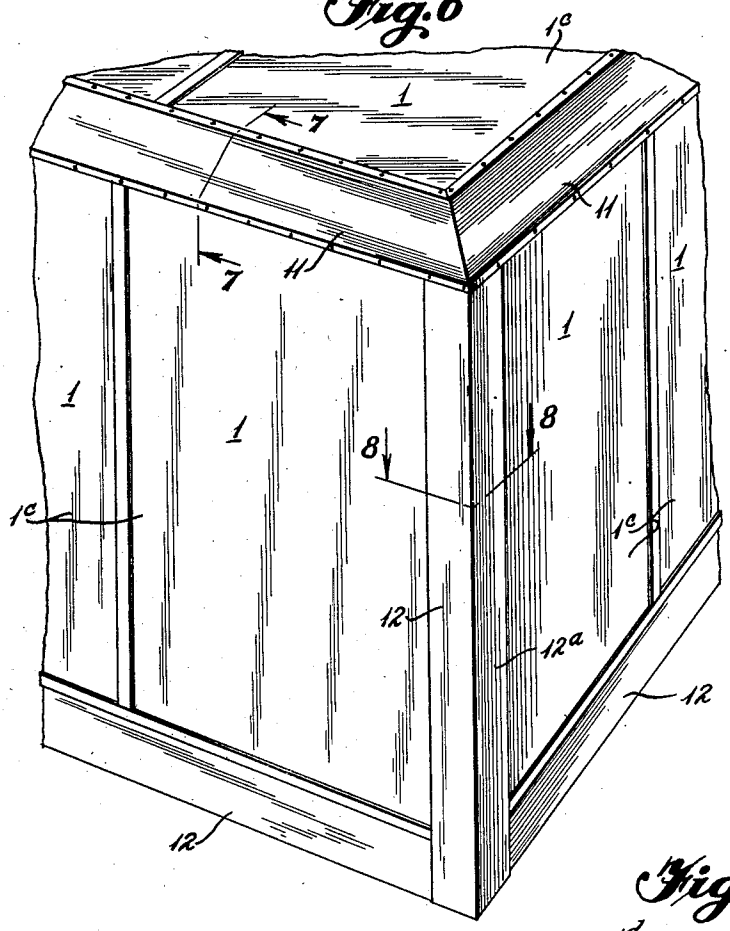


Fig. 7

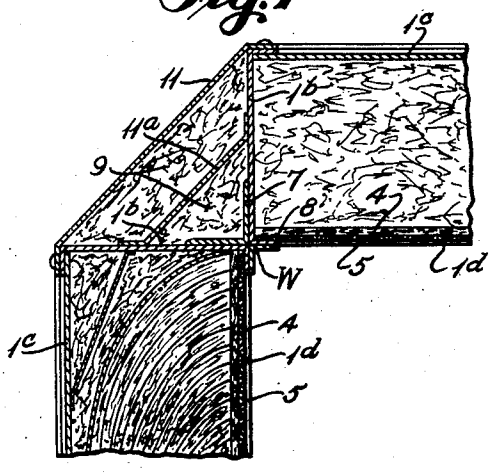
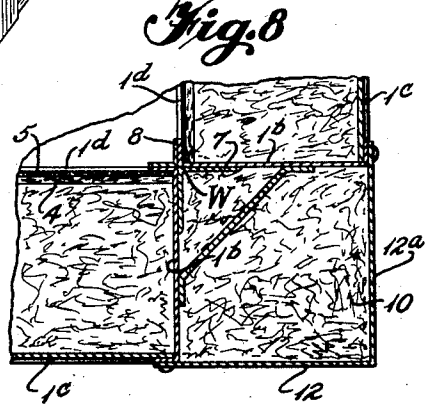


Fig. 8



INVENTOR

William L. Hartsfield

BY Alexander F. Dowell

ATTORNEYS

Feb. 25, 1958 W. L. HARTSFIELD 2,824,618

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Fig. 9

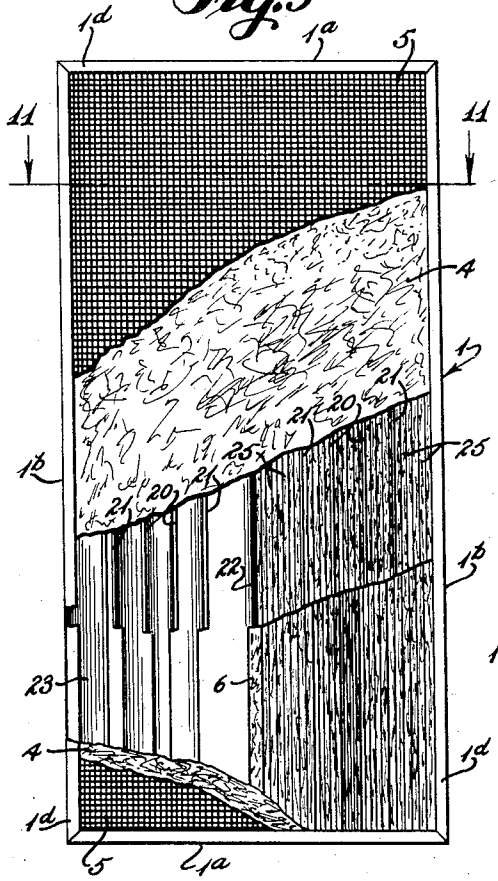


Fig. 10

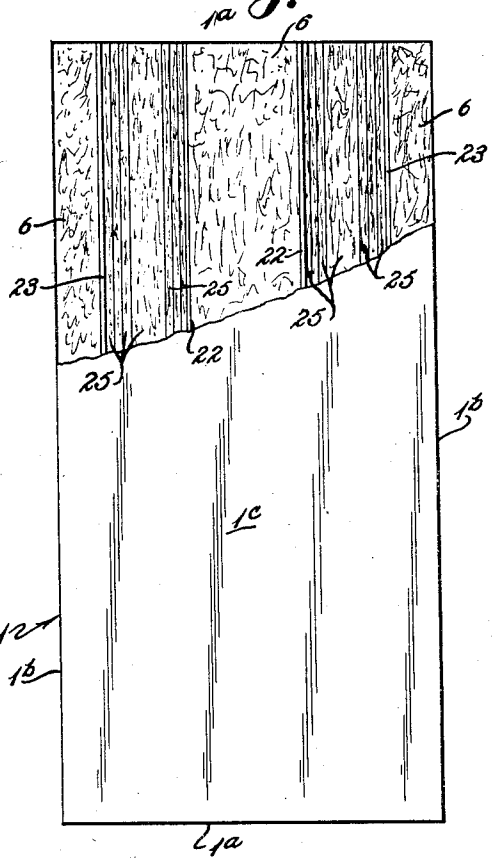
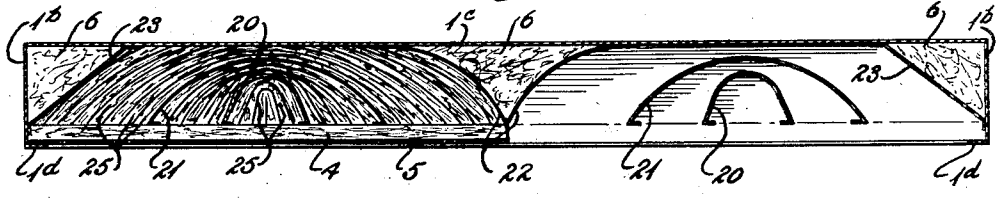


Fig. 11



INVENTOR

William L. Hartsfield

BY Alexander & Dowell

ATTORNEYS

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SOUND ABSORBING WALL PANELS

William L. Hartsfield, Washington, D. C.

Application July 27, 1956, Serial No. 600,631

20 Claims. (Cl. 181—33)

My invention relates to acoustical sound absorbing panels, and more particularly to panels suitable in structure for the construction of soundproof rooms, engine test booths, or other sound-deadening structures.

The principal object of my invention is to provide a novel acoustical panel capable of absorbing, and thereby dissipating, acoustical energy over a wide frequency spectrum which extends the effectiveness further into the low frequency range than heretofore practical with existing panels.

Another primary object of my invention is to provide an acoustical panel which when assembled with other similar panels will form a composite wall, or even a room, having the above-mentioned absorption characteristics, i. e., nearly complete energy absorption with nearly negligible reflection within said range.

A further object is the provision of a panel having an inner or acoustical absorbing face, and having an outer or structural face, said panel effecting a very high degree of attenuation of acoustical energy passing through the panel from one face to the other, in either direction.

Another object of my invention is to provide a panel including a plurality of adjacent acoustical horns, each horn decreasing in cross-sectional area inwardly of a composite acoustical absorbing face, in which face the mouth of each horn lies, and the axis of each horn being curved and disposed at an angle with respect to said composite absorbing face so as to provide the desired acoustical horn length while at the same time providing a panel of minimum dimensional thickness.

Still another object of my invention is to provide a panel of the type above described wherein each of the curved horns is packed with an acoustical absorbing material, the density of the material being relatively low at the mouth of the horn and increasing gradually to a maximum, heavy density, at the small end of the horn. The lower frequency acoustical energy entering the horn travels deep thereinto and as it travels encounters ever-increasing density of the absorbing material, the density increasing gradually and with no definite boundary which might have a tendency to cause reflections of acoustical energy.

A further object of the invention is to provide a panel which is a composite of the horns comprising it, said horns being so nested that their mouths all lie in the plane of the said acoustical absorbing face of the panel, and the walls of the horns being defined by sheet material partitions.

Another object of the invention is to provide a panel, the absorbing face of which includes a covering in the form of a blanket of less-dense absorbing material to absorb high-frequency waves reaching the said face and to prevent reflection thereof by the outer ends of the sheet material partitions, the blanket being capable of ornamentation to provide an attractive and decorative appearance when such panels are used as building units.

An additional object of the invention is to provide a panel having a structurally strong outer surface, which

surface may be acoustically reflective, and the panel exhibiting strong attenuation to any energy attempting to enter the panel through the structural face and travel through the panel toward the said absorbing face, this feature being important when constructing a "soundproof" room.

Yet another object of this invention is to provide a panel which can be readily adapted for use as a door.

Other objects of the present invention will become apparent during the following discussion of the drawings wherein:

Figure 1 is a front view of a panel looking in the direction of the sound-absorbing face, various layers of the panel having been broken away to illustrate the underlying construction.

Fig. 2 is a rear view of a panel wherein the rear sheet material comprising the structural face has been partly broken away to show the underlying construction.

Fig. 3 is an enlarged partial cross-sectional view through the panel along the line 3—3 of Fig. 1.

Fig. 4 is a still further enlarged partial cross-sectional view through the panel serving to illustrate the manner in which the sound-absorbing material is inserted within the horns which comprise the panel.

Fig. 5 is an exploded view showing the different lengths of the various blankets which comprise the absorbing material packed within one horn, the blankets respectively being labeled *a, b, c, d, e, f, g, h, i,* and *j,* and corresponding with the blankets shown in Fig. 4 inserted within the uppermost horn.

Fig. 6 is an outside perspective view of a room which might be constructed employing a plurality of the panels which comprise the subject matter of the present invention.

Fig. 7 is an enlarged cross-sectional view along line 7—7 of Fig. 6.

Fig. 8 is an enlarged cross-sectional view along line 8—8 of Fig. 6.

Fig. 9 is a front view of a modified form of the panel, various layers of the panel having been broken away to illustrate underlying construction.

Fig. 10 is a rear view of the same modified form, wherein the rear sheet material has been partially broken away to show the underlying construction.

Fig. 11 is an enlarged cross-sectional view taken along line 11—11 of Fig. 9.

As shown in a preferred embodiment in the drawings, Figs. 1 and 2, each panel comprises a metal box 1 having closed upper and lower ends 1*a* and having closed right and left sides 1*b*. The rear of the box is also enclosed by a sheet material panel 1*c* and the front of the box may also include a flange 1*d* serving the purpose of reinforcing the box. As best illustrated in Figs. 3 and 4, the inner volume of the box 1 is divided by means of a plurality of sheet material partitions 2 into a plurality of tapered horns H having relatively large mouths opening in a direction away from the rear panel 1*c* of the box, and each horn H tapering inwardly and, as illustrated, downwardly until the volume of each horn decreases to zero. Except for the uppermost partition 2, the remaining partitions each has a flange 2*a* across the end thereof nearest the mouth of the horn, said flanges 2*a* lending rigidity to the mouths of the horns. It is to be observed, in Fig. 3, that the lowermost horn does not actually taper to zero volume but is, in fact, only a relatively small arcuate cavity which does not have as satisfactory characteristics. However, by careful proportioning of the remaining horns within the composite wall panel, the error introduced by the lowermost horn (marked H' in Fig. 3) may be kept to a practical minimum, the horn H' being a good absorber of high-fre-

quency energy and presenting only a small area to low-frequency energy in terms of low frequency wave-lengths.

As best illustrated at the uppermost horn H, in Fig. 4, each of the horns is packed with sound-absorbing material 3, the material preferably used being fiberglass blankets, and blankets of different lengths 3*a*, 3*b*, 3*c*, 3*d*, 3*e*, 3*f*, 3*g*, 3*h*, 3*i*, and 3*j* being used so as to obtain graduation of the density of the fiberglass material. Originally, and before packing into a horn, the various blankets 3 are all of the same density, but the lengths thereof are different as shown in Fig. 5. During the construction of the horns, the upper partition 2 is inserted in the box 1, and then the 3*a*–3*j* blankets are laid in place on the upper partition. At this time the next lower partition 2 is assembled and is so loaded as to compress the blankets 3*a*–3*j* into the shape illustrated in the horn at the upper end of Fig. 4. The process is then repeated by insertion of another group of blankets 3*a*–3*j* on the partition 2 which has been most recently assembled, and so on. It should be apparent that when the padding is assembled in a horn in this manner, the density thereof is altered by compression of the fibreglass blankets 3 rather than by the use of a non-homogeneous material the density of which changes with its length. When all the horns in a wall panel unit have been completed by assembly in this manner, a final fibreglass blanket 4 is laid over the mouths of all of the horns, as shown in Figs. 3 and 4, and a wire mesh screen 5 or the equivalent is then laid over the fibreglass blanket 4, for the purpose of maintaining the latter in position. The blanket 4 or screen 5 or both could be decorated to provide an ornamental and attractive appearance.

As stated above, the discontinuity at the lowermost horn H′ in Fig. 3 is small and, in fact, amounts to a negligible disturbance of the orderly pattern of the panel. This panel is also somewhat different at its upper end where a structural reinforcing member 1*e* may be employed to stiffen the top of the box 1. The space on either side of the stiffener 1*e* is likewise packed with fiberglass of relatively high density, the packing being labeled 6 in the drawings. The purpose of the packing 6 will be hereinafter explained.

Fig. 6 illustrates a soundproof box or room constructed of a plurality of panels 1 each having its sound-absorbing face turned inwardly, and said panels being attached together so as to form a rigid structure.

As is best illustrated in Figs. 7 and 8, when two panels are put together edge-to-edge in a position where they are disposed normal to each other, there results a weak spot in their combined acoustical characteristics, which spot is marked W. Actually, the weak spot W at each junction is merely a line, but it is possible that such a line might leak a considerable amount of energy. It is therefore desirable to employ a pair of angle irons 7 and 8 for the purpose of strengthening the intersection of the panels, and in addition to pack the volume in the space immediately outside of the weak spot W with fiberglass material 9 or 10. This fiberglass material should be confined by further sheet metal structure so as to prevent its escape from the vicinity of the weak spot W. Figs. 7 and 8 show two different suitable structures, the one in Fig. 7 being composed of several diagonal panels 11 and 11*a*, and the structure in Fig. 8 being rectangular in cross-section and comprising a bent panel 12—12*a*.

In view of the fact that it is often as desirable that energy be prevented from entering a room (as shown in Fig. 6) from outside the room as it is desirable to prevent the escape of sound inside of the room to a point outside of the room, I have provided the packing 6 shown at the top of Fig. 3 and also the packing 9 and 10 as shown in Figs. 7 and 8 respectively, so as to attenuate insofar as possible the transfer of sound energy through the panels in either direction.

Figs. 9, 10 and 11 show another modified form of the sound absorbing panel, wherein parts which are similar to those in the previous embodiment are labeled with similar reference characters. This modified form also includes a sheet-material box 1 having a rear surface 1*c* and having sides 1*a* and 1*b* surrounded by a flange 1*d*. The sound absorbing face of the panel is similarly covered by an acoustical blanket 4 held in place by an open-mesh screen 5. The modification of structure in this new form lies in the partitions 20, 21, 22 and 23 which divide the box into a plurality of horns, which, however, are not mutually identical.

These Figures 9–11 illustrate a panel having two nested sets of horns; Fig. 11 showing the left set of horns complete with sound absorbing material 25, which material 25 has been omitted from the right set of horns so as to provide a clearer illustration of the location of the various partitions forming a set of horns. The sound absorbing material 25 may comprise a plurality of blankets of fibreglass graduated in length in a manner analogous to those shown in Fig. 5. The outer edges of the partitions may be flanged over in order to stiffen them, and the three spaces behind the partitions 22 and 23 should be packed full of sound absorbing material 6 so as to attenuate the passage through the panel of sound energy entering through the rear surface 1*c*.

This modified panel is admittedly not as efficient a sound absorber as the preferred embodiment shown in Figs. 1 through 5, but it still exhibits excellent absorbing characteristics and is more economical to manufacture.

Attenuation characteristics

The energy-attenuating characteristics of the present panels vary with the wave length and therefore with the frequency of the incoming energy. The high-frequency energy is relatively easily absorbed and prevented from reflecting and the density of the blanket 4 is about the same as the density of the blankets 3*a*–3*j* at the mouths of the horns. High-frequency sound entering through the screen 5 is pretty well absorbed by the blanket 4 and by the less dense portions of the blankets 3*a*–3*j* in the vicinity of the mouths of the horns, since high-frequency energy does not penetrate very deeply into the horns.

However, as the frequency of the sound entering the panel is reduced, the depth of penetration of the energy into the horns increases. Since it is not practical to manufacture horns having axial lengths anywhere approaching a wave-length of the low-frequency sound energy, the density of the fiberglass material packed into the horns must be increased with depth into the horns.

As stated above, it is extremely undesirable to have abrupt discontinuities in density which may cause reflection of the sounds, and therefore the sound-absorbing material is packed into the horns with gradually increasing density. Near the innermost ends of the horns the density is so great that the fiberglass becomes virtually impenetrable to the sound energy. Even if low-frequency sound should penetrate deep into the horn and then be reflected outwardly, the energy would still have to travel through a sufficient amount of fibreglass packing so that it would be substantially entirely absorbed by the time it reached the mouth of the horn again.

It is also to be noted that because of the angle which the outer portions of the partitions make with respect to any sound wave entering the horn in a direction substantially perpendicular to the plane of the blanket 4, the sound waves reflected from partitions of any horn will tend to be thrown deeper into the horn rather than reflected outwardly in the direction of the blanket 4.

I do not limit my invention to the exact form shown in the drawings, for obviously changes may be made within the scope of the following claims.

I claim:

1. An acoustical panel for absorbing vibrational energy reaching the front face of the panel, comprising a frame; a plurality of acoustical horns in said frame, said horns having open mouths all disposed adjacent one another and

lying in a common plane parallel to the front face of the panel, and said horns reducing in cross-sectional area rearwardly of the panel; and acoustical absorbing material filling each horn, the density of said material being smoothly graduated from a hard-packed density in the rear of each horn to a light density near the mouth of each horn.

2. In a panel as set forth in claim 1, an external blanket of light-density acoustical absorbing material across the face of the panel and overlying the mouths of said horns; and means for retaining said blanket in place against the horns.

3. An acoustical panel for absorbing vibrational energy reaching the front face of the panel, comprising a box having an open front face, a closed rear face, and closed sides; a plurality of acoustical horns mounted in said box, said horns having open mouths all disposed adjacent one another and lying in a common plane parallel with the front of the box, and said horns reducing in cross-sectional area rearwardly of the panel; and acoustical absorbing material filling each horn, the density of said material being smoothly graduated from a hard-packed density in the rear of each horn to a light density near the mouth of each horn.

4. In a panel as set forth in claim 3, an external blanket of light-density acoustical absorbing material across the front face of the panel and overlying the mouths of said horns.

5. In a panel as set forth in claim 4, an open-mesh sheet overlying said external blanket to retain the latter in place, said sheet being attached around its periphery to the sides of the box.

6. In a panel as set forth in claim 3, acoustical absorbing material packed tightly between the horns and the rear and sides of said box to absorb energy entering the box through the rear thereof.

7. An acoustical panel for absorbing vibrational energy reaching the front face of the panel, comprising a box having an open front face, a closed rear face and closed sides; a plurality of partitions each extending from substantially the front face of the box toward the rear face and from one side of the box toward an opposite side to define a plurality of acoustical horns having open mouths lying in a common plane across the front of the box, and said horns reducing in cross-sectional area rearwardly of the panel; and acoustical absorbing material filling each horn, the density of said material being smoothly graduated from a hard-packed density in the rear of each horn to a light density near the mouth of each horn.

8. In a panel as set forth in claim 7, an external blanket of light-density acoustical absorbing material across the front face of the panel and overlying the mouths of said horns.

9. In a panel as set forth in claim 8, an open-mesh sheet overlying said external blanket to retain the latter in place, said sheet being attached around its periphery to the sides of the box.

10. In a panel as set forth in claim 7, acoustical absorbing material packed tightly into the spaces within the box lying between the partitions and the rear and sides of the box, said material absorbing energy entering the box through the rear thereof.

11. An acoustical panel for absorbing vibrational energy reaching the front face of the panel, comprising a box having an open front face, a closed rear face and closed sides; a plurality of curved partitions in said box and each disposed substantially normal to the plane of the front face of the box near the front, and extending rearwardly along an offset curve and terminating tangent

to said rear face, the partitions each extending from one side of the box toward an opposite side to define a plurality of curved nested acoustical horns having open mouths lying in a common plane parallel to said first-mentioned plane, and said horns reducing in cross-sectional area rearwardly of the panel; and acoustical absorbing material filling each horn.

12. In a panel as set forth in claim 11, an external blanket of light-density acoustical absorbing material across the front face of the panel and overlying the mouths of said horns.

13. In a panel as set forth in claim 12, an open-mesh sheet overlying said external blanket to retain the latter in place, said sheet being attached around its periphery to the sides of the box.

14. In a panel as set forth in claim 11, acoustical absorbing material packed tightly into the spaces within the box lying between the partitions and the rear and sides of the box, said material absorbing energy entering the box through the rear thereof.

15. In a panel as set forth in claim 11, the density of said material filling each horn being smoothly graduated from a hard-packed density in the rear of each horn to a light density near the mouth of each horn.

16. In a panel as set forth in claim 15, said material filling each horn comprising a plurality of individual blankets the width of a horn but varying in length, the blankets having their front edges in alignment and their rear edges staggered at different depths in the horn, and the partitions holding the blankets in compression to provide said graduated density.

17. An acoustical panel for absorbing vibrational energy reaching the front face of the panel, comprising a box having an open front face, a closed rear face and closed sides; a plurality of partitions in said box each disposed substantially normal to the plane of the front face of the box near the front and said partitions being dish-shaped and mutually nested in spaced relation, the spacing between adjacent nested partitions decreasing in a direction rearwardly of the front face to form a plurality of tapered horns having open mouths lying in a common plane parallel to said first mentioned plane; and acoustical absorbing material filling each horn.

18. In a panel as set forth in claim 17, an external blanket of light-density acoustical absorbing material across the front face of the panel and overlying the mouths of said horns.

19. In a panel as set forth in claim 17, the density of said material filling each horn being smoothly graduated from a hard-packed density in the rear of each horn to a light density near the mouth of each horn.

20. In a panel as set forth in claim 19, said material filling each horn comprising a plurality of individual blankets the height of a horn but varying in width, the blankets having their front edges in alignment at the mouth of the horn and their rear edges staggered at different depths in the horn, and the partitions holding the blankets in compression to provide said graduated density.

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