May 23, 1939. J. S. PARKINSON 2,159,488

PERFORATED MEMBRANE

Filed Aug. 1, 1935

Fig. 1.

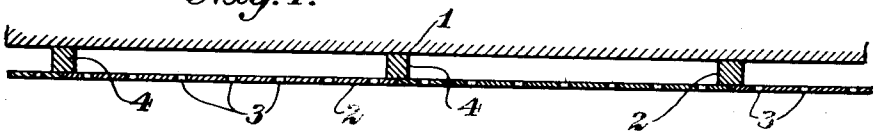


Fig. 2.

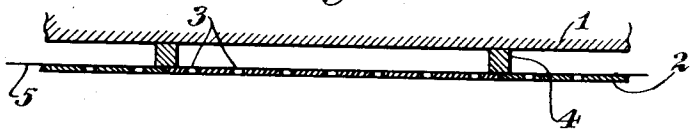


Fig. 3.

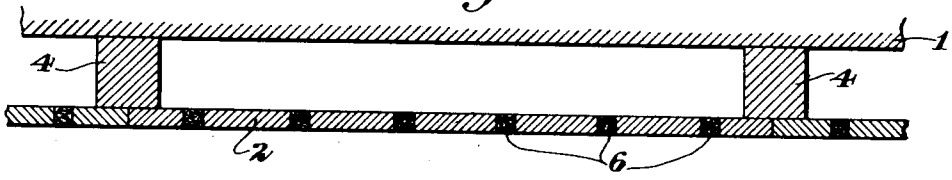


Fig. 4.

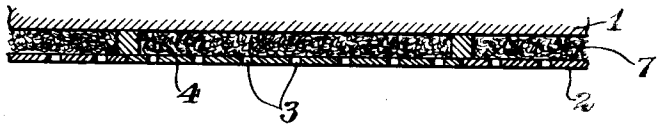


Fig. 5.

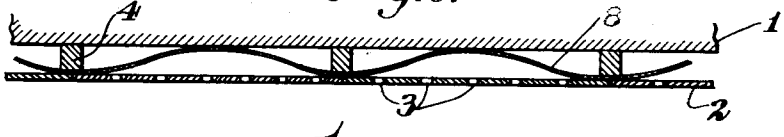
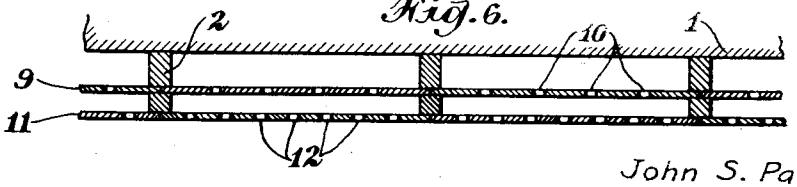


Fig. 6.



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PERFORATED MEMBRANE

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Application August 1, 1935, Serial No. 34,239

10 Claims. (Cl. 20—4)

This invention relates to an acoustical structure comprising an air-impermeable member and a thick facing element defining an air-filled space with the member and provided with openings freely communicating with and adapted to admit incident sound to the said space. The invention relates especially to such a structure in which the system including the air in the said space and openings is of resonant predominate frequency of substantially the frequency of the sound to be absorbed.

It has been customary heretofore to absorb sound in a thick felt or the like, suitably with a perforated thin facing element disposed thereover.

It is an object of this invention to provide a sound-absorbing structure not requiring conventional sound-absorbing material such as felt or any equivalent thereof or, if such material is used, to modify the acoustical properties and produce the greatest absorption in the range of the frequency of the sound to be absorbed. Other objects and advantages of the invention will appear from the detailed description that follows.

A preferred embodiment of the invention is illustrated in the drawing and will be described in connection therewith.

Fig. 1 is a sectional view of a sound-absorbing structure constructed in accordance with the invention.

Figs. 2–6, inclusive, are sectional views of modifications of the invention.

There are shown an air-impermeable backing member 1 such as a permanent wall of a building that is substantially impermeable to air-borne sound, a facing element 2 provided with openings 3 adapted to admit incident sound, and means such as the furring strips 4 for spacing the facing element 2 from the wall 1 at a predetermined distance.

The apertured facing element 2 defines with the member 1 an air-filled space. In the structures shown in Figs. 1–3, 5 and 6, this space communicates freely with the openings in the facing element, in distinction from structures in which a thick fibrous felt or the like is disposed adjacent to the back side of a facing element. The spacing of the members 1 and 2 is such that the system defined thereby, including the air in the said space and in the openings 3 communicating therewith, is of resonant frequency of the order of the frequency of the sound that is to be absorbed. For sound in the usual range of frequency, say, from 128 to 4,096 cycles per second, the facing element may be spaced from the wall by a distance of the order of from one to four inches, suitably two inches.

Depending upon the frequency of the sound to be absorbed, various sizes and spacings of openings 3 may be used, as well as thicknesses of the facing element. I have used to advantage rigid facing elements of asbestos and cement board having a thickness of the order of one-eighth to one-half inch and provided with openings of acoustical properties (permeability to sound) of the order of holes of circular cross section of diameter of one-eighth to one-half inch, spaced on three-eights to one inch centers.

Preferably, the air in the space between the facing element 2 and wall 1 is confined, except for communication with the outside air by means of the openings 3.

With a structure as described and illustrated in Fig. 1 and without the use of any fibrous pad or the like, I have obtained, for example, an absorption in excess of 50 per cent of incident sound of frequency of 256 cycles.

The critical nature of the spacing is illustrated by the results obtained in a typical structure using, as the facing element, a rigid asbestos cement wallboard ¼ inch thick, provided with circular openings of $\frac{5}{32}$ inch diameter, spaced on 1.5 inch centers. This facing element was spaced variously from an air-impermeable member. Test results on absorption of sound of two frequencies follow, the results being subject, it should be understood, to the experimental error or inaccuracy common to acoustical measurements of this nature.

Spacing of facing element from air-impermeable member, inches	Percent absorption of incident sound of frequency	
	256 cycles	512 cycles
1	11	30
2 (average of two results)	51	26
3	38	19
4	34	20

In the modifications shown in section in Fig. 2 a thin porous fabric 5 of the type of a woven textile cloth, a thin felt, or the like is disposed over the back of the facing element. A substantial improvement in the sound-absorption is obtained at selected frequencies; the improvement is much greater than calculated from the additive effects of the cloth and the remainder of the system functioning separately. There has been obtained thus an absorption of about 80

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per cent of incident sound of frequency of 1000 cycles. While the invention is not limited to any theory of explanation of this or other surprising results obtained, it is possible that the concentration of the vibratory movement of air particles in the openings 3, constituting necks of the air-filled system, may result in a high degree of friction and, consequently, of sound-absorption.

In the modification shown in Fig. 3 on a somewhat enlarged scale, as compared to the other figures, sound-absorbing units 6 such as porous wads of rock wool, cotton, or other fibres are disposed in the openings 3, creating frictional resistance at the positions where the air particles move most rapidly, as sound becomes incident upon the system and passes through the openings into the free space behind the facing element.

In the structure shown in Fig. 4, there is combined my improved thick, perforated or otherwise apertured facing element with a pad 7 of felted fibres or other porous sound-absorbing material. With such a combination, it is possible to control the selective absorption for sound and thus to adapt the structure within rather wide limits to absorb preferentially incident sound of selected frequency. Here, also, the member 2 is preferably spaced from the wall as described in connection with Fig. 1, suitably one to four inches and advantageously about two inches.

The nature of modification of sound-absorption in a structure including, for instance, a facing member of very hard pressed fibre board ("hardboard") ¼ inch thick, provided with ⅛ inch holes, on 2 inch centers, and spaced ¾ inch from a wall is shown in the following table of typical test data:

Frequency of sound, cycles	256	512	1,024
Absorption by ¾ inch felt, uncovered	15%	43%	84%
Absorption by system having the same felt in the assembly shown in Fig. 4	80%	23%	8%

In the modification shown in Fig. 5, a space that continuously or periodically varies in depth from side to side of the structure (left to right of the figure) is defined between an air-impermeable member 8 and the perforated facing element. Thus, there may be used a corrugated asbestos millboard or other suitable material defining troughs and crests and the said varying space, whether varying continuously or in steps, adapting the system to show different resonant frequencies, at closely spaced positions, thereby making more uniform the effectiveness of absorption for sound of a wide range of frequencies.

A widening out of the range of frequencies effectively absorbed is obtained, also, in the modification shown in Fig. 6. In this structure, a sheet 9 defines a space with the air impermeable member 1 and is provided with openings 10 communicating freely therewith. A facing element 11 is disposed in front of the sheet 9, defines therewith a second air space and is provided with openings 12 communicating freely therewith. The depth of the space defined between the sheet 9 and the member 1 and/or the spacing apart of the openings in the said sheet is greater or less than the depth of the space between sheet 9 and facing element 11 and/or the spacing apart of the holes 12 therein. The difference adapts the two systems including, respectively, the elements 1 and 9 and 9 and 11, together with the air in the said spaces and openings, to have different resonant frequencies. The effectiveness of the two systems are, therefore, at the maxima in absorbing sounds of different frequencies. If desired, the structure may be expanded by the inclusion of additional spaced perforated sheets, to provide more than two resonant systems. Members 9 and 11 are air-impermeable, except at the openings.

In general, the several factors may be varied more or less independently or jointly. Thus, the resonant frequency for a given system may be decreased by (1) decreasing the size of the openings admitting incident sound to the air-filled space therein (2) increasing the depth of the openings, that is, the thickness of the facing element or sheet provided with the openings, (3) increasing the spacing of the sheet or facing element from the air-impermeable member or wall, and/or (4) increasing the distance of spacing of openings of a given diameter. Conversely, the resonant frequency may be increased by (1) increasing the size of the openings, (2) decreasing the depth thereof, (3) decreasing the spacing of the apertured element from the impermeable member defining therewith the resonant system and/or (4) decreasing the spacing of the openings.

For the best transmission of sound through a perforated or apertured facing element disposed in front of sound-absorption material and spaced from an air-impermeable member, the resonant frequency of the system should be at least as great as the maximum frequency of the sound to be absorbed divided by the square root of 2.

The details that have been given are for the purpose of illustration, not restriction. It is intended, therefore, that variations within the spirit of the invention should be included within the scope of the appended claims.

What I claim is:

1. An acoustical structure for absorbing sound of a selected frequency comprising a substantially air-impermeable backing member, a facing element of a thickness of the order of ¼ inch provided with openings spaced about ⅜ to 1 inch apart at their centers and having each an area of cross-section of the order of a circle ⅛ to ½ inch in diameter and adapted to admit incident sound therethrough, said facing element defining a space with said backing member substantially sealed against the entry of air-borne sounds except through said openings, and air filling the space and openings to constitute a resonant system, the frequency of which is substantially equal to the frequency of the sound to be absorbed.

2. An acoustical structure for absorbing sound of a given range of frequency, comprising a substantially air-impermeable backing member, a facing element of a thickness between ⅛ and ½ inch having openings spaced on ⅜ to 1 inch centers, the cross-sectional area of each of said openings being equal to the area of a circle of ⅛ to ½ inch in diameter, said openings being adapted to admit incident sound therethrough, and said facing element defining a space with said backing member substantially sealed against the entry of air-borne sounds except through said openings.

3. A sound-absorbing structure comprising a substantially air-impermeable backing member, a sheet of a thickness of the order of ⅛ to ½ inch provided with openings spaced about ⅜ to 1 inch apart at their centers, the cross-sectional

area of each of said openings being equal to the area of a circle of the order of ⅛ to ½ inch in diameter, said openings being adapted to admit incident sound therethrough, said sheet and backing member defining an air-filled space substantially sealed against the entry of air-borne sounds except through said openings to form a resonant system having a frequency substantially equal to the frequency of sound to be absorbed, and a facing element disposed in front of said sheet and provided with openings adapted to admit incident sound therethrough, said sheet and facing element defining an air-filled space comprising a second resonant system having a frequency different from the system defined by the said sheet and backing member and which is substantially equal to the frequency of other sound to be absorbed.

4. A sound-absorbing structure comprising a resonant system including a substantially air-impermeable backing member, a perforated facing element of a thickness of the order of ⅛ to ½ inch, said perforations being spaced about ⅜ to 1 inch apart at their centers, the cross-sectional area of each of said perforations being equal to the area of a circle of the order of ⅛ to ½ inch in diameter, said element being spaced from the backing member and defining therewith an air-filled space substantially sealed against the entry of air-borne sounds except through said perforations, and a sound-absorbing material disposed between said element and backing member, the resonant frequency of the said system being at least as great as the maximum frequency of the incident sound divided by the square root of 2.

5. A sound-absorbing structure comprising a substantially air-impermeable backing member, a facing element of a thickness of the order of ⅛ to ½ inch provided with openings spaced about ⅜ to 1 inch apart at their centers, the cross-sectional area of each of said openings being equal to the area of a circle of the order of ⅛ to ½ inch in diameter, said openings being adapted to admit incident sound therethrough and defining a space with the said backing member substantially sealed against the entry of air-borne sounds except through said openings to form a resonant system, and a porous fibrous material disposed at said openings, whereby sound passing through said openings and to said space therebehind is caused to penetrate the porous material.

6. A sound-absorbing structure comprising a substantially air-impermeable backing member, a facing element of a thickness of the order of ⅛ to ½ inch provided with openings spaced about ⅜ to 1 inch apart at their centers, the cross-sectional area of each of said openings being equal to the area of a circle of the order of ⅛ to ½ inch in diameter, said openings being adapted to admit incident sound therethrough and defining a space with said backing member substantially sealed against the entry of air-borne sounds except through said openings to form a resonant system, and a thin porous fabric of the type of a woven textile cloth or thin felt disposed adjacent to and over the back of the facing element, whereby sound passing through the said openings and into the said space therebehind is caused to penetrate the porous fabric.

7. A sound-absorbing structure comprising a substantially air-impermeable backing member, a facing element of a thickness of the order of ⅛ to ½ inch provided with openings spaced about ⅜ to 1 inch apart at their centers, the cross-sectional area of each of said openings being equal to the area of a circle of the order of ⅛ to ½ inch in diameter, said openings being adapted to admit incident sound therethrough and defining a space with said backing member substantially sealed against the entry of air-borne sounds except through said openings to form a resonant system, and a porous sound-absorbing material disposed in the openings in the facing element, whereby sound passing through said openings and into the space therebehind is caused to penetrate the porous sound-absorbing material.

8. A sound-absorbing structure comprising a substantially air-impermeable member, a facing element provided with openings adapted to admit incident sound therethrough, said facing element defining a space with said member substantially sealed against the entry of air-borne sounds except through said openings, said member and element being so shaped and arranged that said space varies in depth to provide a resonant system the frequency of which varies with the variation in depth of said space, whereby sounds of different frequencies will be absorbed.

9. A sound-absorbing structure comprising a substantially air-impermeable member, a facing element provided with openings adapted to admit incident sound therethrough, said facing element defining a space with said substantially air-impermeable member, and said substantially air-impermeable member being so shaped as to cause variation in the depth of said space to provide a resonant system the frequency of which varies with the variation in depth of said space, whereby sounds of different frequencies will be absorbed.

10. A sound-absorbing structure comprising a substantially air-impermeable member, a facing element provided with openings adapted to admit incident sound therethrough, said facing element defining a space with said member substantially sealed against the entry of air-borne sounds except through said openings, said substantially air-impermeable member being so shaped as to cause the depth of the space to continuously vary to provide a resonant system the frequency of which varies with the variation in depth of said space, whereby sounds of different frequencies will be absorbed.

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