April 7, 1959 H. VON MUNCHHAUSEN 2,880,471

SOUND INSULATING STRUCTURES

Filed Feb. 20, 1957

2 Sheets-Sheet 1

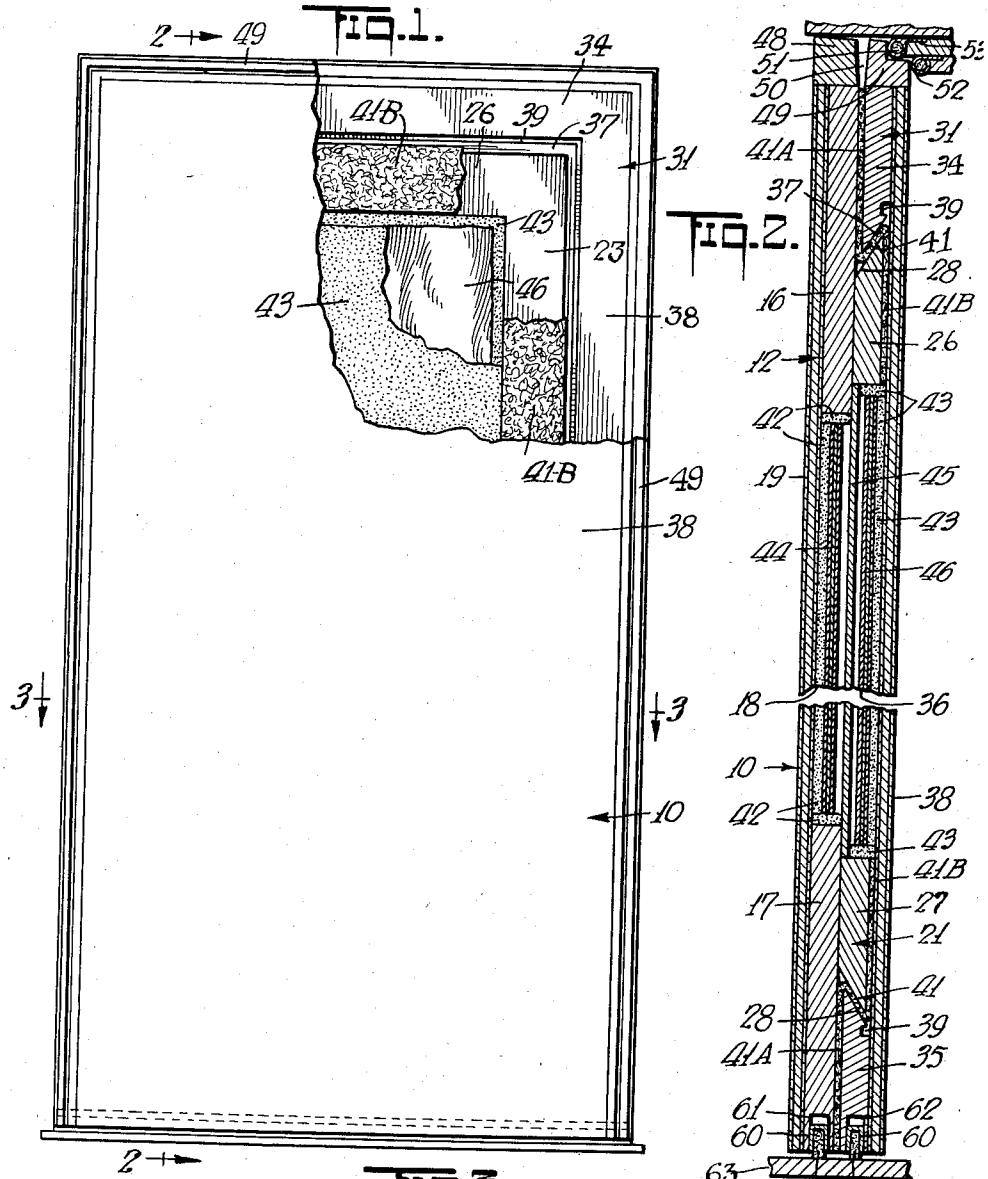


FIG. 1.

FIG. 2.

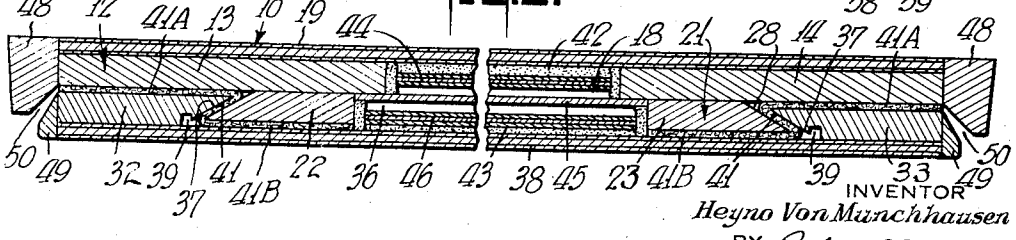


FIG. 3.

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2 Sheets-Sheet 2

FIG. 4.

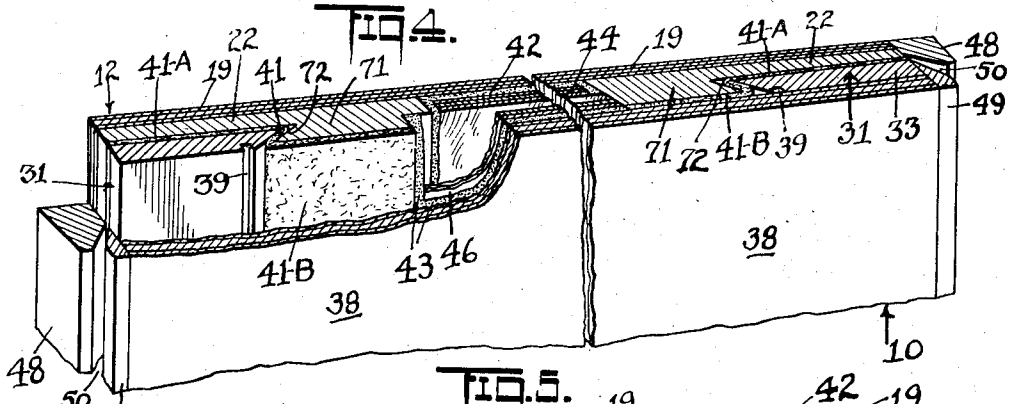


FIG. 5.

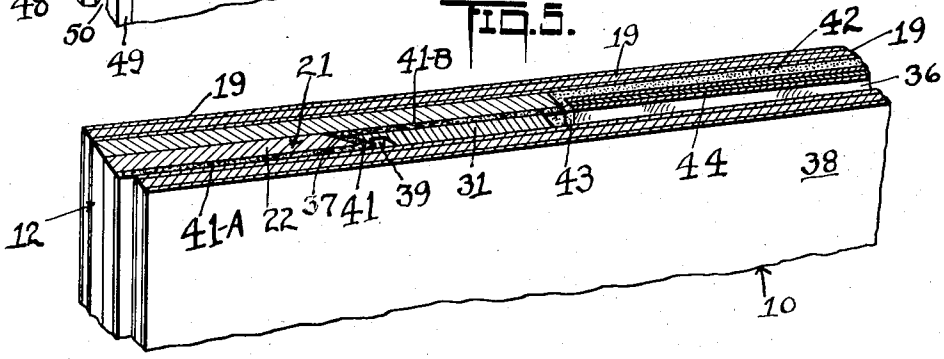


FIG. 7.

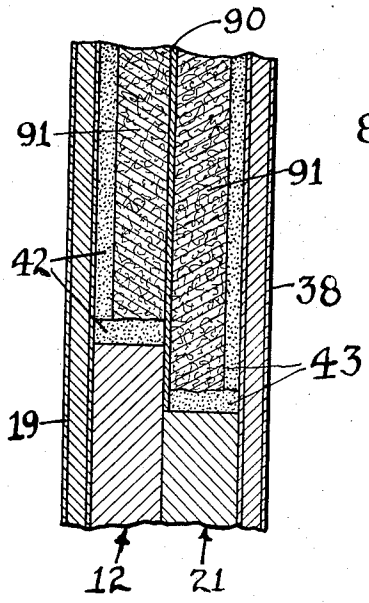
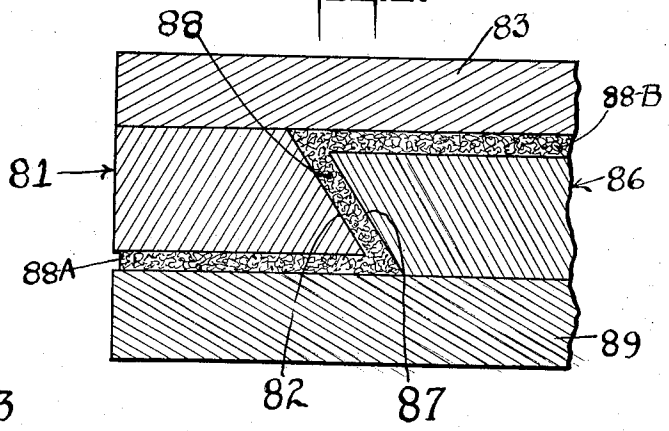


FIG. 6.



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SOUND INSULATING STRUCTURES

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Application February 20, 1957, Serial No. 641,322

15 Claims. (Cl. 20—4)

This application is a continuation-in-part of my co-pending application Serial No. 256,401, filed November 15, 1951, now abandoned, for improvements in Insulating Method and Improvement in Sound Insulating Structural Supports.

The present invention relates generally to a sound insulating structure, and it has specific relation to an insulating structure in the nature of a door, movable partition, window and the like.

The principal aim of an acoustician is to retain wanted sound, to make it more pleasant and to make unwanted sound less disturbing. Essential to the end is the creation of barriers that will keep out noise and protect privacy. This is becoming increasingly important in hotels, offices, factories, laboratories, schools, studios and apartments. A condition where loud noises, such as caused by machinery and/or music, must be kept in or out, or where a near absence of noise is essential, as in a laboratory and sound studio, is frequently referred to as "soundproofness."

Heretofore, the acoustician has employed special construction methods, to-wit: reinforced or double walls, floating designs and special spacing arrangements. It is not too difficult to obtain the desired degree of soundproofness in walls, floors and ceilings of a building, but, when it comes to the doors, movable partitions, windows and the like, it has been impossible heretofore to match to any reasonable degree the sound-proofness of said walls, floors or ceilings without using either two widely spaced doors or a single door that is so thick, unsightly and heavy that it is almost impossible for the average person to open or close the same.

The present invention has as an object to provide a soundproof structure of the character described, which is simple, efficient and economical to construct.

Another object of the invention is the provision of a soundproof structure, such as for example, a door or movable partition, which is compact, similar in size and appearance to a conventional door or partition, light-in-weight and easy to manipulate.

A further object of the invention is to provide a single compactly appearing sound-proof structure having complete discontinuity between its opposite face panels and their respective supporting frame members, whereby sound vibrations striking one face panel cannot be transmitted to the opposite face panel but must pass through a layer of sound vibration insulation material.

Another object of the invention is the provision of a soundproof door and/or partition in which there is a difference in the natural frequencies of their opposite face panels, which have been so constructed as to vary both as to free span and mass, thereby providing a difference in natural frequency responses, preferably disharmonic—the thing that the musician calls "beat," which, as the physicists know, inhibits transmission of vibrations from one taut string or one vibrating panel to another by what is often called "sympathetic resonance."

A further object of the invention is to provide a soundproof door and/or movable partition wherein all the vibration damping features are contained therein, are not unsightly and are not subject to quick deterioration or aging due to exposure of such features to the atmosphere.

Other and further objects and advantages of the invention reside in the detailed construction of the structures, which result in simplicity, economy and efficiency, and which will be apparent from the following description, wherein preferred embodiments of the invention are shown, reference being had to the accompanying drawings, forming a part hereof, wherein like numerals indicate like parts, in which:

Figure 1 is a front elevational view of a sound insulating structure in the form of a door shown mounted in a conventional frame, which has been made in accordance with the principles of the invention and which has parts thereof broken away to better illustrate the features of the construction;

Figure 2 is a vertical sectional view of the structure shown in Figure 1, the same having been taken substantially along the line 2—2 thereof, looking in the direction of the arrows, and showing its spaced sealing gaskets;

Figure 3 is a cross-sectional view of the structure shown in Figure 1, the same having been taken substantially along the line 3—3 thereof, looking in the direction of the arrows;

Figure 4 is a fragmentary perspective view of a modification of the structure shown in Figure 1, having parts broken away to illustrate more clearly the novel features of its construction, wherein the intermediate frame is formed as an integral part of the main frame member, which extends around the inside of the secondary frame member;

Figure 5 is a fragmentary perspective view of a modified form of the structure shown in Figures 1 to 3, wherein the frame members have been reversed and the intermediate frame extends around the outside of the secondary frame member;

Figure 6 is an enlarged fragmentary cross-sectional view of a simplified form which the invention may assume, wherein no intermediate frame or extension member is embodied in the construction; and

Figure 7 is a fragmentary vertical sectional view, on an enlarged scale, showing another form of treatment of the interior spaces of the openings through the main and secondary frame members.

Referring now to the drawings, and particularly to Figures 1 to 3 thereof, the invention is shown in the form of a soundproof door mounted on hinges to a conventional door frame. In this embodiment, the door **10** has a main frame member **12**, which is formed of a pair of laterally spaced stile members **13** and **14** and a pair of vertically spaced rail members **16** and **17** fixed securely in any suitable manner, forming a rectangular frame member having a central opening **18** extending therethrough, which covers a substantial portion of its total area. One side of the main frame member **12** is covered completely by a face panel member **19**, and is preferably made of a heavy plywood, which covers the opening **18**. This face panel member **19** forms one outer side of the finished door **10**, and may be secured to the main frame member **12** in any convenient manner, as by gluing, nailing, doweling, etc.

Mounted fixedly on the opposite or inner side of the main frame member **12** is an extension, which in this form consists of an intermediate frame **21**, which also consists of laterally spaced stile members **22** and **23** and vertically spaced rail members **26** and **27**. This intermediate frame **21** is mounted on the main frame member **12** in any suitable manner, as by gluing, nailing or doweling adjacent to and encircling its opening **18**. The outer peripheral edge of the intermediate frame **21** is of

an irregular shape, preferably in the form of an inwardly sloping taper 28, which is of a simple wedge construction and is adapted for interfitting or interlocking with an oppositely shaped edge to form an integral structure when assembled.

A secondary frame member 31, which is substantially of the size and shape of the main frame member 12 as to its outside dimensions, comprises a pair of laterally spaced stile members 32 and 33 and a pair of vertically spaced rail members 34 and 35 suitably joined to form a rectangular frame structure having a central opening 36 therethrough. The inner peripheral edge of the secondary frame member 31 is provided with an irregular shape, preferably in the form of an outwardly sloping edge 37, which is a simple tapered wedge construction and is adapted for interfitting or interlocking with the oppositely shaped and sloping tapered edge 28 of the main frame member. The outer side of the secondary frame member 31 is covered completely by a face panel member 38, similar to the face panel 19 which closes the opening 36 therethrough. The face panel 38 forms the opposite outer side of the finished door 10, and may be secured to the secondary frame member 31 in any conventional manner, as by gluing, nailing, doweling, etc.

It has been discovered that greater soundproofness may be obtained by using a construction where the opposite sides of the soundproof structure 10 have a difference in natural frequency response. This "beat" may be accomplished in several ways, as for example, by making the main frame member 12 of stiles and rails of a different width and/or thickness from the stiles and rails of the secondary frame member 31, which will, in turn, provide a central opening in each frame member of different dimensions as to height and width. Another way in which "beat" may be obtained is to make the face panel on one side of a different thickness from the face panel on the other side.

It will be obvious from the construction of the secondary frame member 31 that the frames cannot be assembled as separate units and then fastened together, but that the secondary frame member 31 must be assembled when it is being placed in its final position within the main frame member 12, and, after assembly, the face panel 38 of the secondary frame member 31 must be mounted thereon. It is for this reason that the recesses 39 are formed adjacent the inner peripheral edge so that, if glue is used as the fastening means, any excess will drain into said recesses and harden instead of dripping onto and being absorbed by the sound vibration insulation material 41 that is positioned between the two frame members.

Before assembling the secondary frame member 31 to the main frame member 12, a layer of sound vibration insulation material 41, such as felt, is interposed not only between said interlocking frame members but extends outwardly from the interlock in opposite directions and in interposed position between the contiguous surfaces of the frame members and the face panels, as indicated by the numerals 41–A and 41–B. This sound vibration insulation material 41 is preferably not glued or otherwise fastened to said main frame member 12 or to the secondary frame member 31. It is wedged or locked frictionally between the two frame members. It has been found that any fastening means, such as glue, will increase the conductivity of the sound vibration insulation material. It has a tendency to wet the material and then hardens into a solid mass that reduces the sound insulation value of the insulation material.

The entire inner surface area of the face panel 19 of the main frame member 12, which is that portion contiguous to the central opening, and the edges of the rails and stiles forming said opening 18, are covered with a viscous adhesive substance 42, having sound damping properties. Conventional caulking compounds, which have the characteristics of forming a thin outer skin upon oxidation while maintaining a viscous inner state, have been found to be excellent materials for such purposes as they tend to reduce the transmission of sound in a most effective and satisfactory manner.

The entire inner free surface area of the face panel member 38 of the secondary frame member 31, which is that portion contiguous to its central opening 36 except for the area contiguous to the extension of the main frame, and also the adjoining edges of the extension forming said opening, are likewise to be treated with the same viscous adhesive substance, as indicated by the numeral 43.

To further insure against the transmission of sound through the aligned central openings 18 and 36 of the frame members 12 and 31, a sheet of limp material 45 is mounted vertically between said openings and along the medial plane thereof, and mounted in spaced relation thereto intermediate each of said openings are one or more layers of such limp sheet material 44 and 46. Types of limp sheet materials found satisfactory to reduce the transmission of sound are tar papers, roofing materials, uncured composite boards and the like.

When the soundproof door 10 has been assembled, it is advisable to provide its unfinished edge portions with a suitable covering. The sides of the door 10 and its top edge are provided with a pair of spaced strips or bands 48 and 49. It will be noted that each band is secured fixedly, as by gluing or nails, to its respective frame member and face panel, and that there is a narrow air space or gap 50 between said adjacent bands to reduce any sound transmission from one band to the other band.

The sides and top edge of the frames of the door 10 may be further sealed by the use of spaced soft and compliant gaskets 51 and 52, having a core of foam rubber, which is enclosed within an encircling cover whose superposed ends extend outwardly and away therefrom to provide suitable means 53 for attachment to the door frame. The bottom edge of the door 10, which rides over the saddle 63, is provided with a pair of spaced vertically extending felt strips 58 and 59. In the arrangement shown, these strips 58 and 59 are mounted fixedly, as by gluing, in a slidable frame structure 60 mounted within the recesses 61 and 62. The details of such mountings have no bearing on the present invention.

Referring now to Figure 4, there is shown a modified construction, in which the intermediate frame member 21 has been formed integrally with the main frame member 12 as an extension or raised platform 71. The extension or platform 71 has its outer peripheral edge 72 tapered inwardly. In all other respects, the construction is identical to that shown in Figures 1 to 3, both inclusive.

Referring now to Figure 5, there is shown a modification of the construction shown in Figures 1 to 3, both inclusive, wherein the intermediate frame 21 extends around the outside of the main frame member 12 . This construction is substantially a reverse of the construction shown in Figures 1 to 3, but, in all other respects, the constructions are identical.

There is shown in Figure 6 a simplified form which the invention may assume, which is more economical and especially suitable for movable partitions. In this modification, a main frame 81, comprising laterally spaced stiles and vertically spaced rails, provides a rectangular frame member having a central opening therethrough substantially identical to the opening 18. The inner peripheral edge of the main frame member 81 is shaped irregularly, preferably in the form of a taper, as best shown at 82. The main frame member 81 has a face panel 83 attached to its outer side in any convenient manner, as by gluing. The face panel 83 may be made of wood or any composite board material such as are commonly referred to in the building trade as pressed board, panel board, a stiff fiber board and the like.

A secondary frame member **86**, comprising laterally spaced stiles and vertically spaced rails, provides a rectangular frame member adapted to fit within the inner periphery of the main frame member **81**, and it has a central opening therethrough of different dimensions from the central opening through the main frame member **81**. The outer peripheral edge **87** of the secondary frame member **86** is also shaped irregularly, preferably in the form of a taper opposite to the taper of the main frame member **81**, so that upon assembly said irregularly shaped peripheral edges **82** and **87** will form an interlock. A layer of sound vibration insulation material is interposed between said interlocking edges **82** and **87** of said frame members **81** and **86**, as indicated by the numeral **88**. It will be noted that the material **88** also extends in a continuous sheet or layer in opposite directions from said interlock so as to be interposed between the contiguous surfaces with any members either adjacent thereto or connected to the opposite frame. In the illustration shown, the sound vibration insulation material **88–A** is extended between the main frame member **81** and the face panel **89** attached to and covering the secondary frame member **86** in one direction, and in the opposite direction between the secondary frame member **86** and the face panel **83** attached to and covering the main frame member **81**, as indicated at **88–B**. It will also be noted that the face panels **83** and **89** are of different thicknesses. It will be appreciated that, in this simplified construction, the face panel **89** may not be attached to its secondary frame member **86** until after the frame members **81** and **86** have been assembled with the sound vibration insulation material **88**, **88–A** and **88–B** interposed therebetween.

Referring now to Figure 7, there is shown a modified soundproofing treatment for the openings **18** and **36** of the frame members **12** and **21**, respectively, wherein a sheet of limp material **90** is mounted vertically between said openings. The spaces on opposite sides of said limp sheet material **90** and the inner surfaces of the viscous damping materials **42** and **43** are filled with a loose fibrous material **91**, such as rock wool, fiber glass, woodfelt and the like, having sound damping characteristics.

The terms "sound vibration insulation material," "sound damping" and "vibration damping" have been used to denote materials and methods used to substantially increase that which the physicist calls "sound transmission loss." The term "limp sheet material" has been used to denote any sheet material such as tar paper, roofing materials of the asphalt type, paper and the like having sound damping properties. The term "fibrous material" is used to denote any material composed of or having the characteristics of fibers, such as wood shavings, rock wool, fiber glass and the like.

Although I have shown in detail only a few of the modifications which the invention may assume, it will be readily apparent to those skilled in the art that many further modifications may be made therein without departing from the spirit thereof or from the scope of the appended claims.

What I claim is:

1. In a sound insulating structure, a main frame member having an opening therethrough, said main frame member comprising laterally spaced stiles and vertically spaced rails, a face panel attached to the outer side of said main frame member and covering said opening, said main frame member having one peripheral edge shaped irregularly to form part of an interlock, a secondary frame member having an opening therethrough, said secondary frame member comprising laterally spaced stiles and vertically spaced rails, a face panel attached to the outer side of said secondary frame member and covering said opening, said secondary frame member having one peripheral edge shaped irregularly to interlock with the irregularly shaped edge of said main frame member when said members are assembled with their face panels positioned outwardly, and a layer of sound vibration insulation material interposed between said interlocking frame members and between the contiguous surfaces of the members connected thereto.

2. In a sound insulating structure, a main frame member having an opening therethrough, said main frame member comprising laterally spaced stiles and vertically spaced rails, a face panel attached to the outer side of said main frame member and covering said opening, said main frame member having its inner peripheral edge shaped irregularly to form part of an interlock, a secondary frame member having an opening therethrough, said secondary frame member comprising laterally spaced stiles and vertically spaced rails, a face panel attached to the outer side of said secondary frame member and covering said opening, said secondary frame member having its outer peripheral edge shaped irregularly to interlock with the irregularly shaped edge of said main frame member when said members are assembled with their face panels positioned outwardly, and a layer of sound vibration insulation material interposed between said interlocking frame members and extending between any adjacent surfaces of said face panels.

3. In a sound insulating structure, a main frame member having an opening therethrough, said main frame member comprising laterally spaced stiles and vertically spaced rails, a face panel attached to the outer side of said main frame member and covering said opening, said main frame member having its inner peripheral edge shaped irregularly to form part of an interlock, a secondary frame member having an opening therethrough, said secondary frame member comprising laterally spaced stiles and vertically spaced rails, a face panel attached to the outer side of said secondary frame member and covering said opening, the opening through the main frame member being of a different size from the opening in the secondary frame member, said secondary frame member having its outer peripheral edge shaped irregularly to interlock with the irregularly shaped edge of said main frame member when said members are assembled with their face panels positioned outwardly, and a layer of sound vibration insulation material interposed between said interlocking frame members and between the contiguous surfaces of said face panels.

4. In a sound insulating structure comprising a main frame member having an opening therethrough, a face panel member attached to the outer side of said main frame member and covering said opening, a secondary frame member having an opening therethrough, a face panel member attached to the outer side of said secondary frame member and covering said opening, one of said frame members having an extension on its inner side having an edge shaped to form part of an interlock, the other frame member having an edge shaped to interlock with the shaped edge of the extension of the main frame when said main and secondary frame members are assembled with their face panels positioned outwardly, and a layer of sound vibration insulation material interposed between the adjacent surfaces of said interlocking frame members and between the adjacent panel members.

5. In a sound insulating structure comprising a main frame member having an opening therethrough, a face panel member attached to the outer side of said main frame member and covering said opening, a secondary frame member having an opening therethrough, a face panel member attached to the outer side of said secondary frame member and covering said opening, the face panels being of different thicknesses, one of said frame members having an extension on its inner side which has one edge shaped irregularly to form part of an interlock, the other frame member having its adjacent edge shaped irregularly to interlock with the irregularly shaped edge of said extension when said main and secondary frame members are assembled with their face panels positioned

outwardly, and a layer of sound vibration insulation material interposed between the adjacent surfaces of said interlocking frame members and between the adjacent panel members.

6. In a sound insulating structure comprising a main frame member having an opening therethrough, a face panel member attached to the outer side of said main frame member and covering said opening, a secondary frame member having an opening therethrough, a face panel member attached to the outer side of said secondary frame member and covering said opening, the opening in one of said frame members being of a different size from the opening in the other frame member, one of said frame members having an extension on its inner side which has one edge shaped irregularly to form part of an interlock, the other frame member having an opposite edge shaped irregularly to interlock with the irregularly shaped edge of said extension when said frame members are assembled with their face panels positioned outwardly, and a layer of sound vibration insulation material interposed between the adjacent surfaces of said interlocking frame members and between the adjacent panel members.

7. In a sound insulating structure comprising a main frame member having an opening therethrough, a face panel member attached to the outer side of said main frame member and covering said opening, a secondary frame member having an opening therethrough, a face panel member attached to the outer side of said secondary frame member and covering said opening, one of said frame members having an intermediate frame mounted on its inner side which has one edge tapered to form part of an interlock, the other of said frame members having an opposite edge tapered oppositely to interlock with the tapered edge of the intermediate frame when said main and secondary frame members are assembled with their face panels positioned outwardly, and a layer of sound vibration insulation material interposed between the adjacent surfaces of said interlocking frame members and between the adjacent panel members.

8. In a sound insulating structure comprising a main frame member having an opening therethrough, a face panel member attached to the outer side of said main frame member and covering said opening, a secondary frame member having an opening therethrough, a face panel member attached to the outer side of said secondary frame member and covering said opening, one of said frame members having an intermediate frame mounted on its inner side which has one edge shaped irregularly to form part of an interlock, the other of said frame members having an opposite edge shaped irregularly to interlock with the irregularly shaped edge of the intermediate frame when said main and secondary frame members are assembled with their face panels positioned outwardly, a layer of sound vibration insulation material interposed between the adjacent surfaces of said interlocking frame and between the adjacent panel members, and a layer of viscous sound vibration damping material covering the inner areas of said face panels co-extensive with the openings extending through said main and secondary frame members.

9. In a sound insulating structure comprising a main frame member having an opening therethrough, a face panel member attached to the outer side of said main frame member and covering said opening, a secondary frame member having an opening therethrough, a face panel member attached to the outer side of said secondary frame member and covering said opening, one of said frame members having an intermediate frame mounted on its inner side which has an edge shaped irregularly to form part of an interlock, the other of said frame members having an opposite edge shaped irregularly to interlock with the irregularly shaped edge of the intermediate frame when said main and secondary frame members are assembled with their face panels positioned outwardly, a layer of sound vibration insulation material separating the adjacent surfaces of said interlocking frame members and separating the adjacent surfaces of said frame members and face panel members, a layer of viscous sound vibration damping material covering the inner areas of said face panels co-extensive with the openings extending through said main and secondary frame members, and a sheet of limp sheet material extending across said openings.

10. In a sound insulating structure comprising a main frame member having an opening therethrough, a face panel member attached to the outer side of said main frame member and covering said opening, a secondary frame member having an opening therethrough, a face panel member attached to the outer side of said secondary frame member and covering said opening, said main frame member having an intermediate frame mounted on its inner side which has one edge shaped irregularly to form a part of an interlock, the secondary frame member having an opposite edge shaped irregularly to interlock with the irregularly shaped edge of the intermediate frame when said main and secondary frame members are assembled with their face panels positioned outwardly, and a layer of sound vibration insulation material separating the adjacent surfaces of said interlocking frame members and separating said frame members from their adjacent panel members.

11. In a sound insulating structure comprising a main frame member having an opening therethrough, a face panel member attached to the outer side of said main frame member and covering said opening, a secondary frame member having an opening therethrough, a face panel member attached to the outer side of said secondary frame member and covering said opening, said secondary frame member having one edge shaped irregularly to form part of an interlock, said main frame member having an opposite edge shaped irregularly to interlock with the irregularly shaped edge of the secondary frame member when said main and secondary frame members are assembled with their face panels positioned outwardly, and a layer of sound vibration insulation material separating the adjacent surfaces of said interlocking frame members and separating said frame members from their adjacent panel members.

12. In a sound insulating structure comprising a main frame member having an opening therethrough, a face panel member attached to the outer side of said main frame member and covering said opening, a secondary frame member having an opening therethrough, a face panel member attached to the outer side of said secondary frame member and covering said opening, one of said frame members having an intermediate frame mounted on its inner side which has one edge shaped irregularly to form part of an interlock, the other of said frame members having an opposite edge shaped irregularly to interlock with the irregularly shaped edge of the intermediate frame when said main and secondary frame members are assembled with their face panels positioned outwardly, a layer of sound vibration insulation material interposed between the adjacent surfaces of said interlocking frame members, and a limp sheet of material extending across each of the openings in each of said main and secondary frame members.

13. In a sound insulating structure comprising a main frame member having an opening therethrough, a face panel member attached to the outer side of said main frame member and covering said opening, a secondary frame member having an opening therethrough, a face panel member attached to the outer side of said secondary frame member and covering said opening, one of said frame members having an intermediate frame mounted on its inner side which has one edge shaped irregularly to form part of an interlock, the other of said frame members having an opposite edge shaped irregularly to interlock with the irregularly shaped edge of the intermediate frame when said main and secondary fram

members are assembled with their face panels positioned outwardly, a layer of sound vibration insulation material interposed between the adjacent surfaces of said interlocking frame members and extending between the adjacent panel members, a layer of viscous sound vibration damping material covering the inner areas of said face panels and frame members co-extensive with said openings, and a limp sheet of material dividing the common passageway formed by said openings.

14. In a sound insulating structure comprising a main frame member having an opening therethrough, a face panel member attached to the outer side of said main frame member and covering said opening, a secondary frame member having an opening therethrough, a face panel member attached to the outer side of said secondary frame member and covering said opening, one of said frame members having an intermediate frame mounted on its inner side which has one edge shaped irregularly to form part of an interlock, the other of said frame members having an opposite edge shaped irregularly to interlock with the irregularly shaped edge of the intermediate frame when said main and secondary frame members are assembled with their face panels positioned outwardly, a layer of sound vibration insulation material interposed between the adjacent surfaces of said interlocking frame members and extending between the adjacent panel members, a layer of viscous sound vibration damping material covering the inner areas of said face panels co-extensive with the openings extending through said main and secondary frame members, and fibrous material filling the remaining spaces of said openings.

15. In a sound insulating structure comprising a main

frame member having an opening therethrough, a face panel member attached to the outer side of said main frame member and covering said opening, a secondary frame member having an opening therethrough, a face panel member attached to the outer side of said secondary frame member and covering said opening, one of said frame members having an intermediate frame mounted on its inner side which has one edge tapered in one direction to form part of an interlock, the other of said frame members having an opposite edge tapered oppositely to interlock with the tapered edge of the intermediate frame when said main and secondary frame members are assembled with their face panels positioned outwardly, a layer of sound vibration insulation material interposed between the adjacent surfaces of said interlocking frame members and extending between the adjacent panel members, a layer of viscous sound vibration damping material covering the inner areas of said face panels contiguous with said openings, a limp sheet of material extending across said openings along their common plane, and a layer of fibrous material filling the remaining spaces of said openings.

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