ACOUSTIC INSULATING MATERIAL
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Abstract of the Disclosure
An acoustical insulating member comprises composites of metallic foil bonded to laminae of flexural damping material. The composites are separated by spacer sheets having voids or air cells over large portions of their surfaces. The flexural damping material minimizes acoustical transmission through the composites in the diaphragm mode, and the voids provide impedance mismatches which minimize transmission in the compression mode.

Background of the Invention
Field of the invention
This invention relates to acoustical insulating material. More particularly, it relates to a material suitable for the acoustical isolation of small lightweight enclosures.

Prior art
Effective acoustical barriers generally employ one or both of two insulating effects. The first of these is the attenuation through a panel resulting from a large mass per unit area. Thus, lead sheets are often used as acoustical insulation because of the high density of this material. Other metals have been proposed for the same reason, although the thicknesses would have to be proportionately greater than the thicknesses of lead sheets. For example, some investigators have found steel to be an even better material than lead, weight for weight, presumably because of the greater stiffness of steel.

Nonhomogeneous structures are also used for acoustical insulation. Such structures are essentially rigid sandwich-like arrangements in which the attenuation largely occurs in the transfer of acoustical energy from a layer of one material to a layer of a different material.

These prior arrangements are generally characterized by a large mass or substantial thickness if a high degree of acoustical attenuation is to be realized. The mass and thickness required are excessive in many cases even in building structures where room-to-room acoustical isolation is the object. In smaller structures these attributes or requirements can be intolerable. For example, there are small acoustically-sensitive instruments which require isolation from environmental sounds. The bulk or mass of many of the prior acoustical insulating materials will cause a very great proportional increase in the size or weight of the overall package, a problem that is particularly vexing if the instrument is to be portable.

Objects of the Invention
Accordingly, a principal object of the invention is to provide an improved acoustical insulating material that is relatively thin and light in weight.

Another object of the invention is to provide an insulating material that is particularly useful in small structures, for example, instrument enclosures.

A further object of the invention is to provide acoustical insulating material of the above type which has a significant degree of strength, so as to contribute to the integrity of the structure in which it is incorporated.

Yet another object of the invention is to provide acoustical insulating material of the above type which can be subjected to forming operations without undue degradation of its insulating characteristics.

A further object of the invention is an acoustical insulating material providing the foregoing characteristics without an unduly high cost.

The invention accordingly comprises an article of manufacture possessing the features, properties, and the relation of elements which will be exemplified in the article hereinafter described.

Summary of the Invention
A sheet of insulating material embodying the invention comprises a plurality of thin sheets or laminae having a high acoustical impedance bonded to sheets of flexural damping material. The resulting composites are spaced apart by grid-like textured sheets so that a large portion of the surface area of each of the composites faces a void. That is, a large portion of the acoustical path between the composites is through air.

There are two basic modes of sound transmission through a panel. The first of these is a diaphragm or "drum-head" mode in which the entire panel moves to and fro in synchronism with an acoustical driving force on one side. This motion then sets up similar acoustic waves in the air on the other side of the panel.

The second mode of transmission is by way of vibration of the panel. That is, compressional waves, similar to those in air, enter the panel on one side and are similarly retransmitted into the air on the other side of the panel.

Several features of the invention combine to reduce transmission in the diaphragm mode. In the first place, a multi-ply sandwich of the above construction has an inherent overall rigidity to a sound wave, particularly if some of the laminae incorporated in the sandwich are metal sheets. These sheets function in much the same manner as the metallic skins in sandwich constructions used for structural rigidity in panels of various types. Thus, in combination with the damping material they largely inhibit acoustical transmission by diaphragm-like flexure of the entire panel. These same metal sheets also function to attenuate compressional mode transmission, as discussed below.

The individual composites of high-impedance laminae and damping laminae are also subject to diaphragm mode transmission. However, they span the short distances across the openings in the grid-like separating sheets and are relatively stiff over such intervals. Moreover, the damping sheets are preferably arranged to provide a form of viscous damping so as to be relatively stiff at acoustical frequencies, while at the same time absorbing a substantial portion of the flexural energy that may be transmitted into the composites.

Compressional mode attenuation is provided by the repeated transfers of acoustical energy between the high impedance composites and the low impedance air passages between them. This attenuation occurs at each interface between low and high impedance media. The acoustical waves are reflected from these interfaces, and thus the energy within each medium is reflected back and forth and progressively dissipated between such reflections. The high impedance is provided preferably by metallic sheets which can be thin and also of a relatively lightweight metal such as aluminum.

Brief Description of the Drawing
For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawing, which is a cross-section of an insulating panel incorporating the invention.
As shown in the drawing, a typical insulating panel made in accordance with the invention comprises a series of high-impedance composites bonded to intervening separators. Each of the composites includes a lamina of relatively strong, high-impedance material, generally a metal such as aluminum. A damping lamina is bonded to at least one, and preferably both, sides of the lamina.

The damping lamina preferably incorporates a material that has both flexural and compressional damping characteristics, as well as adhesive properties. Thus, the sheet is self-adherent to the high-impedance sheet. For example, the laminae may take the form of thin sheets of tissue paper impregnated with polyisobutylene, a material often used as a pressure-sensitive adhesive.

The separators may simply be textured paper similar to ordinary paper towels. Indeed, a very satisfactory material is a paper towel marketed by Scott Paper Company under the designation “Scott 250.” This material has surface voids approximately one-sixteenth inch across, separated by ridges covering approximately 50 percent of the surface area. In addition, or alternatively, the surfaces of the composites or the laminae may be textured or corrugated to provide the desired air path transmission.

As an example, a panel constructed of the above materials, with the laminae being of aluminum foil approximately 0.001 inch thick and having eight layers of the composites, has a thickness of approximately 0.1 inch and a weight of approximately 0.03 oz. per square inch. Yet it compares favorably in attenuation characteristics with a sheet of lead approximately 0.067 inch thick and weighing approximately 0.4 oz. per square inch.

In addition to its relatively light weight and small thickness, an acoustical barrier incorporating the invention has a relatively low cost. Moreover, it can be formed into various shapes by heating it so as to weaken the bonds provided by the laminae and thereby permitting neighboring laminate to slip with respect to each other as the sheet is bent. The material also has substantial structural rigidity and can thereby contribute to the overall strength of a housing or wall in which it is incorporated.

It will thus be seen that the objects set forth above, among those made apparent from the preceding description, are efficiently attained and, since certain changes may be made in the above article without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. As an insulating material a sandwich comprising
   A. first and second composites, each composite including
   (1) a first lamina of high acoustical impedance material,
   (2) at least a second lamina of flexural damping material bonded to a first surface of said lamina,
   B. a spacer lamina disposed between said composites,
   C. at least one of said lamina having surfaces with voids over substantial areas thereof, whereby a substantial portion of acoustical energy transferred between said composites passes through air.

2. The material defined in claim 1 in which each of said composites includes a third lamina of flexural damping material bonded to the other surface of said first lamina.

3. The material defined in claim 1 in which said damping material is an adhesive that bonds said second and third laminae to said first laminae and said spacer.

4. The material defined in claim 2 in which said damping material is an adhesive bonding said second and third laminae to said first lamina.

5. The material defined in claim 1 in which said spacer has a grid-like surface.

6. The material defined in claim 1 in which said high-impedance material is a metal.

7. The material defined in claim 2 in which said high-impedance material is a metal.

8. The material defined in claim 7 in which
   A. said damping material is polyisobutylene, and
   B. said spacer is of paper.

9. As an acoustical insulating material a sandwich comprising
   A. a plurality of composites, each composite including
      (1) a first lamina of high-impedance material,
      (2) at least a second lamina of flexural damping material bonded to a first surface of said first lamina,
   B. spacer laminae disposed between and bonded to said composites, and
   C. surfaces of laminae having voids over substantial areas thereof, whereby a substantial portion of energy transferred between successive composite passes through air.

10. The material defined in claim 9 in which each of said composites includes a third lamina of flexural damping material bonded to the other surface of said first lamina.

11. The material defined in claim 10 in which said flexural damping material is an adhesive bonding said second and third laminae to said first lamina and to said spacers.

References Cited

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U.S. CL X.R.