United States Patent

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[54] **LIGHTWEIGHT, LOW SOUND TRANSMISSION PARTITION**
6 Claims, 6 Drawing Figs.

[52] **U.S. Cl.** **181/33**
[51] **Int. Cl.** **E04b 1/86**
[50] **Field of Search** 181/33, 33.1, 33.11

[56] **References Cited**

UNITED STATES PATENTS

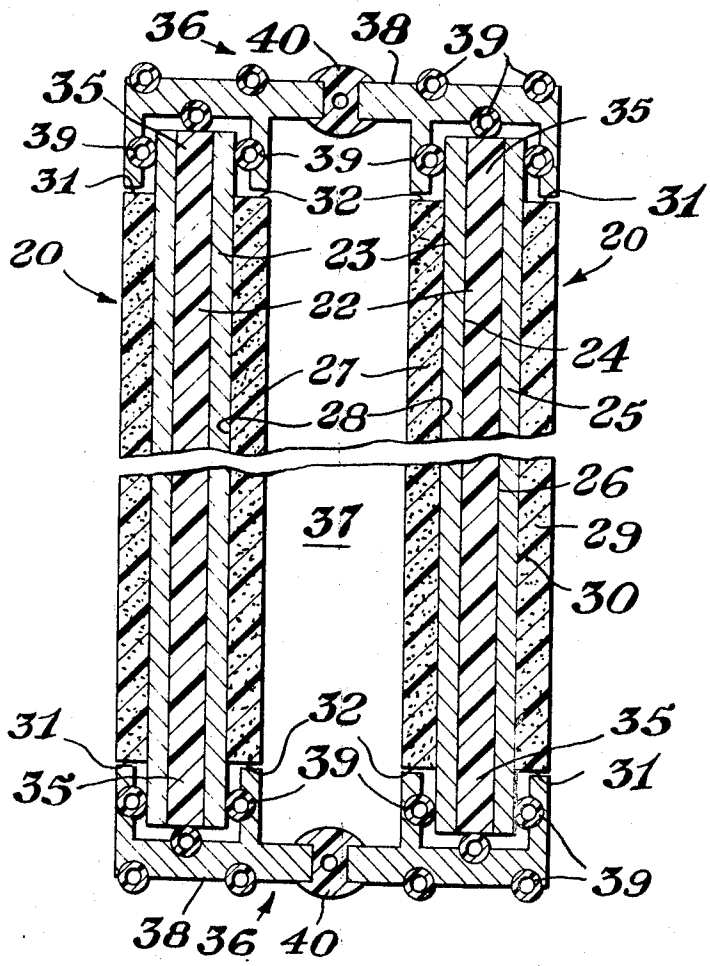
2,199,946	5/1940	Barnhart	181/33.1(UX)
2,880,471	4/1959	Von Munchhausen	181/33.1(UX)

FOREIGN PATENTS

921,161	1/1947	France	181/33.1(UX)
1,263,131	4/1961	France	181/33.1(UX)
412,923	7/1934	Great Britain	181/33.1(UX)
581,207	10/1946	Great Britain	181/33.1(UX)
1,052,865	12/1966	Great Britain	181/33.1(UX)

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ABSTRACT: An acoustical partition comprising at least two panels generally parallel to each other and maintained in a spaced apart relationship to define an air space between adjacent panels, each such panel having a stiff, impermeable, sheet-like member coated on at least the side thereof facing the defined air space with a layer of a porous, flexible foam.



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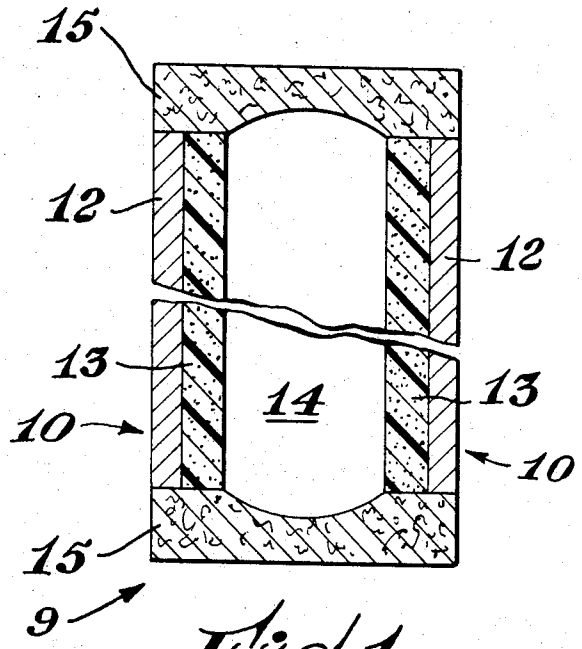


Fig. 1

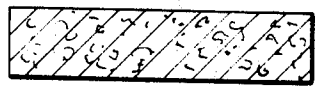


Fig. 1a

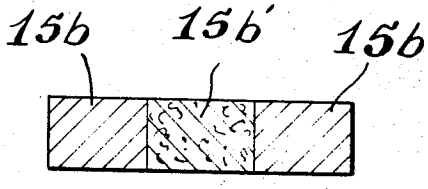


Fig. 1b

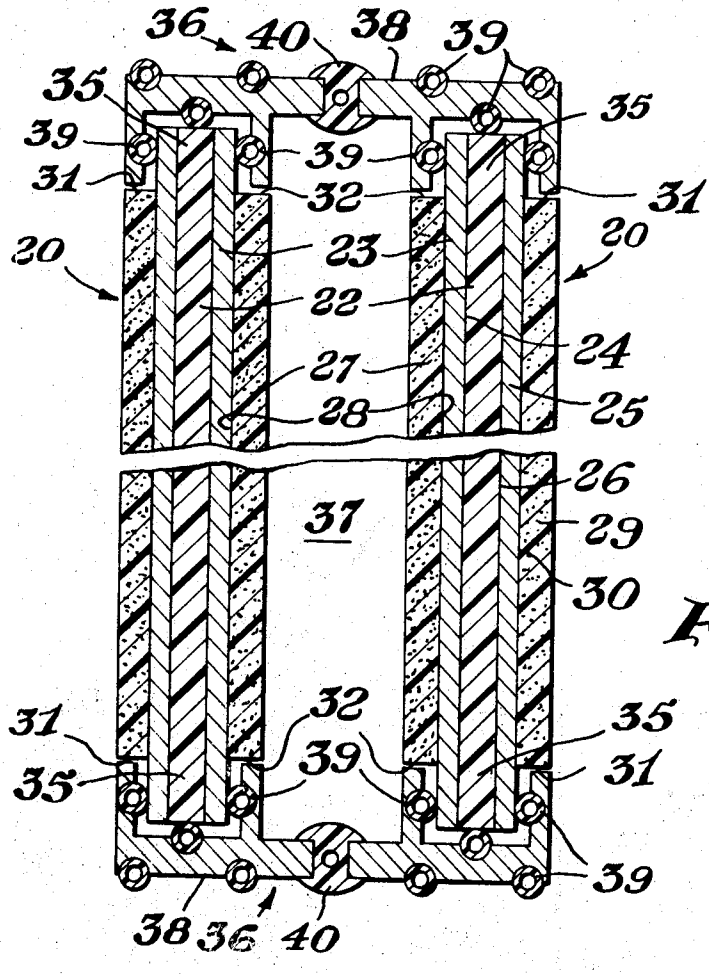


Fig. 2

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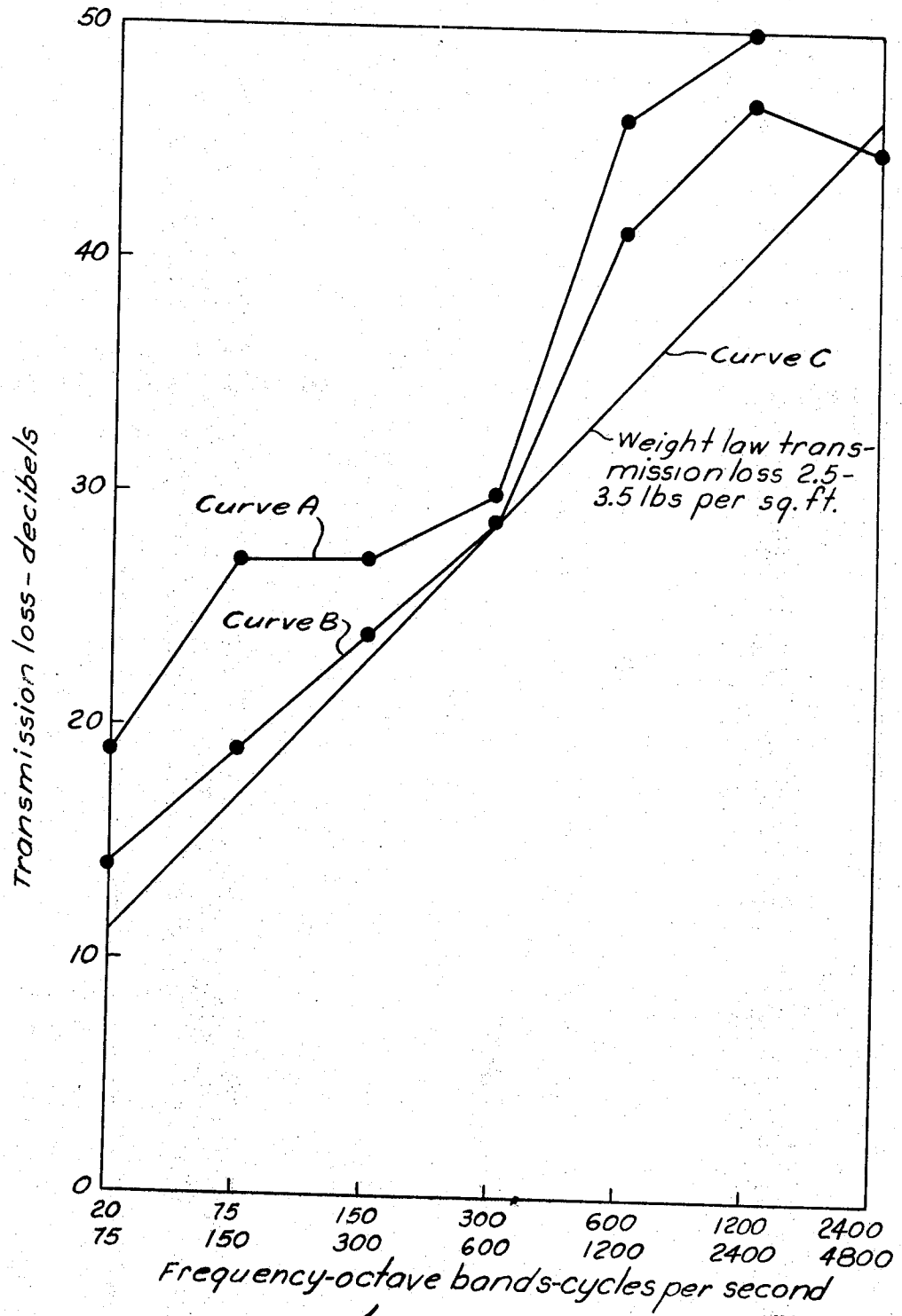


Fig. 3

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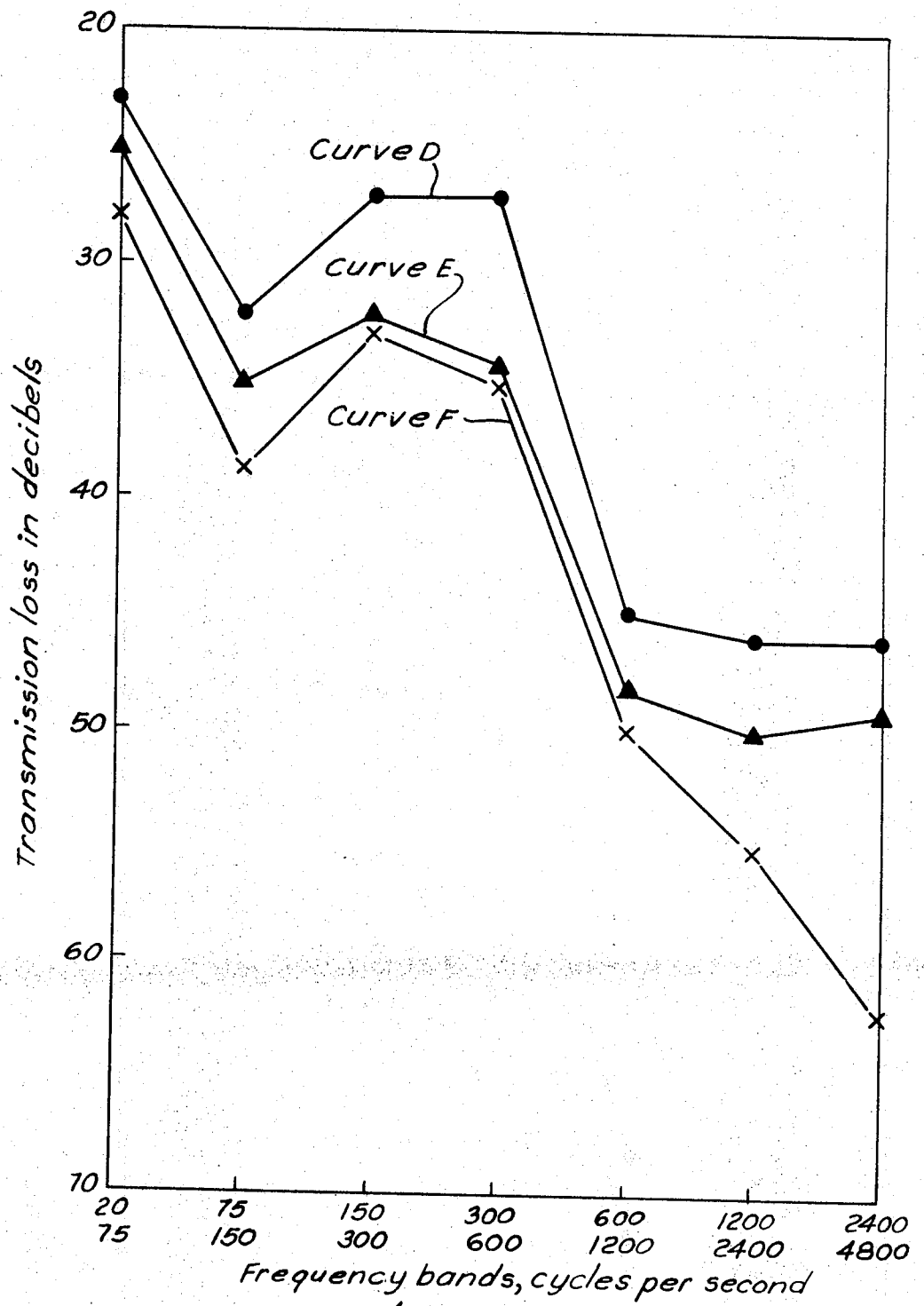


Fig. 4

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LIGHTWEIGHT, LOW SOUND TRANSMISSION PARTITION

BACKGROUND OF THE INVENTION

This invention relates to lightweight acoustical partitions having improved sound attenuation, and more particularly, to acoustical partitions having at least two panels which are maintained in a spaced apart relationship to define an air space between the adjacent panels.

Acoustical partitions have been widely employed in the interiors of various enclosures such as rooms, offices, hospitals, auditoriums, machinery spaces and the like to eliminate objectionable reverberations and reduce the transmission and intensity of sounds. However, to produce a desirable sound barrier having the structural rigidity required, partitions or walls are generally formed of materials having a sufficiently large mass so that the mass of material in itself creates a sound barrier. Such a sound barrier reduces the sound propagated therethrough to an exponential degree provided that the material is impervious to air flow. Unfortunately, materials economically feasible for use in panels if used in the requisite amount to yield the desired attenuation of sound would be particularly unsuitable for partitions or walls, primarily because of excess thickness or weight particularly when such partitions are of the movable type.

In order to overcome the disadvantages of weight and thickness, it has been the practice in the art to construct partitions of two or more thin sheet or panel members rigidly affixed to each other so as to form a stiff partition. Said partitions, when exposed to the range of sound frequencies normally associated with speech do not achieve the sound level reduction characteristically observed in the heavier and thicker partitions. In fact, transmission loss characteristics of these partitions having rigidly attached members are often so low that the sound is actually propagated through the partition. Such sound propagation through the partition is caused by the rigidity of construction of the partition so that when sound strikes one of the stiff side members, the latter flexes and vibrates along its entire area, and the other side member is also caused to vibrate in substantial synchronization therewith. As a result sound is caused to be emitted from the other side wall.

To improve the acoustical properties of such partitions, it is known that if an air space is interposed between the stiff side members that sound propagation is substantially reduced. However, even in these improved partitions sound absorption and reduction of sound transmission is not as great as is often desired. Transmission of sound through these partitions is caused primarily when sound causes one stiff side member to vibrate, which in turn sets the air in the air space between the stiff side members into vibration. The vibrating air causes the opposite stiff side member to vibrate which in turn sets into vibration the air on the opposite side of the partition.

In order to overcome the acoustical problems arising from use of lightweight partitions, it would be highly desirable to provide a thin, lightweight partition having better sound absorption and vibration dampening properties.

SUMMARY OF THE INVENTION

Briefly described, the present invention is a relatively thin, lightweight partition having much improved acoustical properties, particularly in regard to sound absorption and vibration dampening, said partition comprising at least two panels generally parallel to each other, said panels being maintained in a spaced apart relationship to define a continuous air space between adjacent panels. Each such panel has a stiff impermeable, sheetlike member having affixed on at least the side thereof facing the resulting continuous air space between the panels a layer of porous, flexible foam. By the term "continuous air space" is meant one which is unbroken by a solid structural connecting means such as a porous interconnecting layer or a honeycomb structure. Preferably the panels are adjoined at their edges with a visco-elastic connecting means.

The layers of porous, flexible foam affixed to the interior surfaces of the stiff side members in combination with the air space between the members provide a means for inhibiting the transfer of vibrations of one stiff outer member to the other. The gaseous medium of the air space is not stiff and can sustain vibration without transmitting the back and forth motion to the other side member, except at certain resonant frequencies. At these resonant frequencies, *i.e.*, frequencies in which the velocity of the bending wave of the side member coincides with velocity of sound in the air space, the partition would be quite transparent to sound if the layers of the porous, flexible foam did not face the defined air space. By the term "-bending wave" is meant a motion operating back and forth which is thought to cause standing waves in the air space. As a result of positioning the layers of foam on the interior walls of the partition, the layers act as sound -absorbent blankets which reduce standing sound waves in the air space and dampen the back and forth vibrations of the side members appreciably.

The thin, lightweight partitions of this invention serve as effective acoustical walls, and are especially useful in enclosures such as offices, hospitals, schools, rooms and other associated areas.

The invention possesses other advantageous features some of which with the foregoing will be set forth at length in the following description with those forms of the invention which have been selected for illustration in the drawings accompanying and forming a part of the present specification.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, various forms of the invention are shown, but it is to be understood that it is not limited to such forms since the invention as set forth in the claims may be embodied in a plurality of forms.

In the Drawings:

FIG. **1** is a cross-sectioned end elevation view of an acoustical partition in accordance with this invention;

FIG. **1***a* and **1***b* are cross-sectioned end elevation views of a means for connecting two panels;

FIG. **2** is a cross-sectioned end elevation view of a preferred acoustical partition in accordance with this invention;

FIG. **3** graphically depicts the transmission loss at various frequencies of a partition having the interior surfaces of the panels of the partition covered with latex foam versus the transmission loss at the same frequencies of a partition having bare interior surfaces; and

FIG. **4** graphically depicts the transmission losses at various frequencies of different partitions.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Referring now more particularly to the drawings, FIG. **1** is a cross-sectioned end elevation view of an acoustical partition comprising the essential elements of the novel partitions of this invention. This partition **9** comprises at least two panels **10** having an impervious stiff member **12**, preferably composed of a rigid material in the form of thin slabs or sheets having the desired length and width and a thickness ranging from about one-fourth to about 1 inch. The stiff members may have planar or curved geometry. The face elevation of the stiff members may have any shape, for example, triangular, rectangular, trapezoidal, hexagonal, octagonal, circular, elliptical and the like. Each stiff member has a layer **13** of a flexible, porous foam affixed on one side. Beneficially for most applications, the foam layer has a thickness from about one-fourth to about 1 inch. The panels are generally parallel and spaced apart to define a continuous air space **14** having a width from about one-half to about 6 inches. The panels are oriented such that two layers **13** of flexible, porous foam face the air space. The panels **10** are adjoined, preferably at their edges, by a connecting means **15** sufficient to maintain the panels in good structural integrity for the designed purposes of the partition, the means **15** being preferably of visco-elastic material in

order that transmission of sound through the means is minimized. A visco-elastic material aids in dampening vibrations which would readily pass through more rigid connecting means. It is understood that the connecting means may consist entirely of the visco-elastic material as illustrated in FIG. 1*a*, or it may comprise two rigid panel holding members **15***b* and a visco-elastic material **15***b'* connecting said panel holding member as illustrated in FIG. 1*b*.

FIG. **2** illustrates a preferred acoustical partition in accordance with this invention which has two panels **20**, each consisting of a core **22** of a visco-elastic material, a first stiff member **23** affixed to surface **24** of the core and a second stiff member **25** affixed to surface **26** of the core **22**, a first layer **27** of a flexible, open cell foam affixed to surface **28** of the first stiff member **23** and a second layer **29** of a flexible, open cell foam affixed to surface **30** of the second stiff member **25**, said layers having dimensions and being positioned on the stiff members such that the affixed stiff members and core extend beyond the end surfaces **31** and **32** of the layers to form a tongue **35**. The panels **20** are mirror images of each other; therefore the number in the drawing which refers an element of one panel is also applicable to the corresponding element of the other panel. The two panels **20** are oriented in a parallel fashion and are adjoined together with connecting means **36** such that the panels are spaced apart from each other to enclose an open space **37** with the layers **27** of flexible, open cell foam facing the open space **37**. Said connecting means **36** comprise an insulated visco-elastic midsection **40**; rigid peripherally disposed panel holding members **38**, each having a recess for receiving and holding an edge of a panel **20** and a flange extending generally normal to the panel **20** and inwardly to the visco-elastic midsection which connects opposed panel holding members together; and a plurality of hollow acoustical energy absorbers **39** of a visco-elastic material partially imbedded in the surfaces of the panel holding members. In an especially preferred embodiment, the visco-elastic midsection is H-shaped with a hollow in the midsection of the H. A tongue **35** of a first panel is inserted into the recess of a first panel receiving member **38** of a first connecting means **36** such that the surfaces of the tongue **35** rest entirely on the hollow absorbers **39** and in a similar manner a tongue of a second panel is inserted into the recess of the second panel receiving member of the first connecting means. The tongues on the opposite ends of the first and second panels are likewise inserted in a second connecting means **36** identical to the first.

The exterior surfaces of the partition are covered with a decorative material such as a vinyl coating, fiber, fabric, paper and the like where desired or required.

For the purposes of showing the distinct advantages of this invention, a first partition is constructed of an aluminum frame and two side panels having a 100 mil thick chlorinated polyethylene core laminated on both sides with aluminum sheets having a thickness of 12½ mils, each panel also having an inner ¼ inch thick layer of latex foam and an outer ¼ inch thick layer of latex foam having a fiber cover. The panels are adjoined at their edges by an adjoining means, as described in the above-described exemplary preferred embodiment, such that the partition has an inch of air space between the panels.

A second partition is similarly constructed except it has no inner or outer layers of latex foam and encloses a 2 inch air space between the panels.

The sound transmission loss in decibels for each of the two partitions is determined by measuring the drop in sound intensity when the particular partition is inserted into a 6 inch air space between a plywood shell housing a sound transmitting device and a plywood shell housing a sound recording device. The plywood shells are carefully insulated with polyurethane foam to minimize sound leakage through the outside and to reduce structural vibrations.

FIG. **3** shows the sound transmission losses of the two partitions at various frequencies. Curve A represents the transmission loss of the first partition, Curve B represents the transmission loss of the second partition and Curve C represents the transmission loss of a solid wall having an average weight between 2.5 and 3.5 lbs./sq. ft. The first and second partitions have average weights falling within this range. As evidenced in FIG. **3** the first partition which has the structure of the partitions of this invention has greater transmission losses over a wide range of frequencies than is observed with a solid wall having the specified density. In contrast thereto, the second partition, which is not an embodiment of this invention, has a transmission loss at 300 to 600 cycles/second barely equal to that of the solid wall at this frequency and at 2,400 to 4,800 cycles/second the transmission loss for the second partition is actually less than that of the solid wall.

For the purposes of further comparison a third partition is constructed of two ¼ inch thick hardboard panels generally parallel and adjoined peripherally at their edges with a connecting means similar to that shown in FIG. **2** to enclose a 2 inch air space between the adjacent panels. A fourth partition has a structure similar to the third partition except that the sides of the panels facing the enclosed air space are coated with a ⅜ inch thick layer of foam rubber. A fifth partition has a structure similar to the fourth partition except that the exterior sides of the panels are coated with a ⅜ inch thick layer of the latex foam rubber and a thin fibrous cover.

FIG. **4** shows the sound transmission loss at various frequencies of the three partitions. Transmission loss is determined according to the technique described for FIG. **3**. Curve D represents the transmission loss in decibels of the third partition, Curve E represents the transmission loss for the fourth partition and Curve F represents the transmission loss for the fifth partition. As evidenced in FIG. **4** the bare-sided third partition shows poor transmission losses at 150 and 300 cycles/second. In contrast thereto, the partitions having the interior sides of their panels covered with a layer of latex foam rubber show substantially improved transmission losses in this frequency range. A comparison of Curves E and F shows that covering the exterior sides of the panels with latex foam rubber is not as effective in increasing transmission loss as covering the interior sides of the panels with latex foam of the same thickness.

Materials suitably used as stiff members are fairly rigid, impermeable materials such as the hard metals, *e.g.*, steel, aluminum, alloys thereof and the like; wood and wood veneer; hard resinous materials, *e.g.*, resinous sheet reinforced with glass fiber; plastic-metal laminates, plastic cores covered with a hard metal skin, *e.g.*, chlorinated polyethylene covered with an aluminum skin; and other well-known stiff substances.

Suitable porous, flexible foams include foamed plastic materials having flexible character such as synthetic rubber, polyvinyl chloride, polyurethane and other plastic materials of open cell construction. An open cell foam has a pattern of interconnecting internal holes which provide a maze or labyrinth to aid in trapping sound waves. By "open cell foam" is meant a cellular foam in which the cells are either all intercommunicating or partly intercommunicating. A suitable foam has a resilient character and a structural body sufficient to permit its being cemented directly to a stiff member without additional structural mounting or covers. Preferred flexible, porous foams are the foamed plastics, especially the open cell types such as latex foam rubber. Representative of latexes used in making open cell foams include the natural rubber and synthetic latexes and mixtures thereof. Specific examples of synthetic latexes include latexes of polybutadiene, styrene/butadiene copolymers, butadiene/acrylonitrile copolymers, chloroprene homopolymers and copolymers, and so forth.

Preferred synthetic latexes having very desirable properties such as durability, good color, good resiliency and heat aging resistance, are prepared from the so-called reactive latex compositions comprising a polymer having at least one pendant reactive substituent group and intimately admixed therewith an aqueous or water-miscible solution or an aqueous dispersion of a coreactive material containing one or more carbon atoms and additionally which has at least two of certain substituent groups coreactive with the reactive groups on the

latex polymer. By reactive groups is meant such groups as carboxy, sulfo, amino, hydroxyl, carboxyamido and the like. The preferred reactive latexes, suitable water-dispersible coreactive materials, and method for the preparation thereof are described more fully in U.S. Pat. No. 3,215,647 which is incorporated herein in its entirety.

The layers of porous, flexible foam are laminated to the stiff members by cementing the two components; by applying a wet froth of a plastic material to the stiff member and then post-curing the froth; and other known techniques.

The visco-elastic material used in the connecting means dampens the vibrations passing from one panel to the rigid end of the connecting means and which would otherwise pass undampened to the other rigid end of the connecting means and then into the opposite panel. Representative of suitable visco-elastic materials are those which are well-known as dampening materials. Examples include rubber, flexible, rubbery thermoplastic, lapped layers of dampening tape, appropriately impregnated felt materials and the like, with rubber in the form of hollow rubber tubing and flexible rubbery thermoplastics such as chlorinated polyethylene being preferred. The proportion of visco-elastic material used in the connecting means is dependent upon the rigidity desired in the connecting means. Generally, however, a piece of visco-elastic material having a thickness from about one-sixteenth to about 1 inch inserted between the rigid components of the connecting means effectively dampens vibrations passing from one rigid component to the other.

While the invention has been heretofore specifically described as being a sound-absorbing partition, it is understood that a structure according to that described in FIG. 1 can be applied in construction of cabinets, rooms, furniture, musical instruments, recording apparatus, etc. Therefore, while certain preferred embodiments of the invention have been specifically illustrated and described, it is understood that the invention is not limited thereto as many variation will be apparent to those skilled in the art and the invention is to be given its broadest interpretation within the terms of the following claims.

I claim:

1. An acoustical partition having improved sound attenuation comprising at least two panels generally parallel to each other, said panels adjoined at the edges thereof with a visco-elastic connecting means and thereby maintained in a spaced apart relationship to define a continuous air space between adjacent panels, each such panel having a stiff impermeable, sheetlike member having affixed on at least the side thereof facing the defined air space a layer of porous, flexible foam.

2. The partition according to claim 1 wherein the porous, flexible foam is an open cell latex foam.

3. The partition according to claim 1 wherein said panels are adjoined peripherally about the edges thereof to enclose a continuous air space.

4. The partition according to claim 3 wherein the connecting means has rigid panel holding members and visco-elastic means connecting the opposed said members together.

5. An acoustical partition having improved sound attenuation comprising at least two panels generally parallel to each other, said panels adjoined peripherally about the edges thereof with visco-elastic connecting means to maintain said panels in a spaced apart relationship and to enclose a continuous air space, each of said panels having a stiff impermeable, sheetlike member having affixed on at least the side thereof facing the enclosed air space a layer of porous flexible foam, said visco-elastic connecting means having rigid panel holding members and visco-elastic material connecting opposed said holding members together, each of said rigid panel holding members having a recess for receiving and holding an edge of the panel and a flange extending generally normal to the panel and inwardly to the visco-elastic means connecting said opposed panel holding members together.

6. The partition according to claim 5 wherein both sides of each stiff impermeable sheetlike member have affixed thereto a layer of porous, flexible foam.