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SOUND CONTROL PRODUCT

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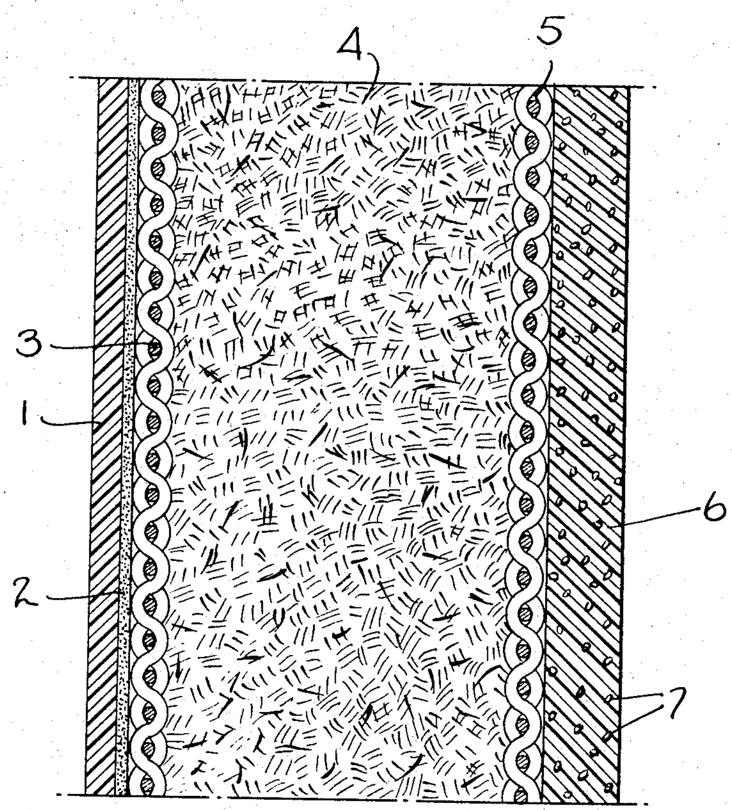

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SOUND CONTROL PRODUCT

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This application is a continuation-in-part of our co-pending application Ser. No. 195,420, filed May 17, 1962 and now abandoned.

This invention is concerned with a novel acoustical product useful for reducing sound level. More particularly it is concerned with a flexible film bonded to the surface of an open weave fabric so as to provide a reinforced film. The film is characterized as substantially sound transparent at low frequencies and substantially sound reflective at high frequencies. Further, it is concerned with novel combinations including such reinforced film with other acoustical materials.

We have discovered that certain plastic films have the unusual property of being substantially sound transparent at low frequency and substantially sound reflective at high frequency. In the products of this invention we take advantage of this property by bonding the film to the surface of a loosely woven fabric to provide a structure which reduces sound transmission by reflecting high frequency sound back towards the sound source. In combination with other acoustical materials the novel reinforced films of this invention may also be employed to reduce the sounds level of both high and low frequency sounds.

In addition to its value as an acoustical product, the novel product of this invention is also useful to protect other sound level reducing media.

Sound absorbers in common use are most often fibrous or granular materials. In conventional applications there is often little or no provision for (1) protection against mechanical shock and abrasion, (2) protection from damage caused by water vapor or vapors by other volatile substances, and (3) protection from detrimental materials such as oil, hydrocarbon fuels, caustic chemicals, sea water and other corrosive substances. Because of this failure to protect many sound absorbent systems substantially lose their effectiveness after a relatively short period of use. It is well known, for example, that fibrous and granular materials lose almost all their sound absorbing qualities after being wetted by any form of moisture. In many applications the absorbers are damaged by impact or abrasion. For optimum utility, length of service, and minimum repair and replacement, it is essential that the sound level reducing materials be protected as much as possible from the aforesaid damaging influences. Preferably this protection should be on all surfaces.

To provide this highly desirable protection is not a simple problem. One cannot simply select any substance to cover the acoustical material since the selected substance must be one which does not substantially alter the protected material's natural characteristics or function. To do so would be to defeat the purpose of having the sound absorbing materials, i.e. to achieve noise reduction. The ideal protective substance should complement and protect the accoustical material. The products of this invention not only achieve these desirable ends, but also make their own independent contribution to sound level reduction.

The product of this invention comprises a plastic film characterized by sound transparency at low frequencies and sound reflection at high frequencies. It is reinforced by being bonded to a loosely woven fabric. It is flexible

and can be used to cover and protect acoustical materials in a wide variety of locations. Thus it can be used in combination with sound reducing materials upon a wall or a ship's bulkhead. It can be used to cover acoustical substances wrapped around a pipe or a plurality of pipes. Similarly it can be employed in conjunction with an acoustical framework surrounding and encasing an engine, generator and other noise source to maintain a low sound level in a room where the noise source is located.

A plastic film which is especially useful in this invention is a polyester film prepared as a high molecular weight condensation product of ethylene glycol and terephthalic acid, with a melting point of about 250–255° C., a density of about 1.39, and a refractive index of about 1.655. It is sold under the trademark Mylar. It is substantially water vapor proof and has a high degree of chemical resistance being impervious to many chemicals including hydraulic fluids, sea and bilge waters, oils and acids. It is light transparent and yet can be colored if desired to enhance its appearance. It forms a tough flexible film having good tear resistance. It is self-extinguishing. Most important of all, it is substantially sound transparent at low frequencies and substantially sound reflective at high frequencies, although there is a limited amount of transparency at high frequency and reflectance at low frequency.

Other plastic films which may be useful in the invention include cellulose derivatives; polyolefins; vinyl polymers derived from vinyl chloride, vinyl acetate, vinylidene chloride and the like.

The reinforcing fabric may be selected from any yarn which can be woven into a thin, open weave fabric. Suitable natural and synthetic yarns include, for example, cotton, silk, nylon, rayon, asbestos and glass. Here again the preferred fabric will depend upon the conditions of use. Asbestos is particularly well suited and preferred because it is economical and it may be loosely woven into a flexible fabric while retaining high strength and tear resistance. Further, it is resistant to flame and chemicals. Of course, it is always feasible to utilize a fabric which is not normally flame resistant, and to make it so by chemical treatment, for example, with ammonium or alkali metal fluoborate.

The purpose of the fabric is to lend structural support to the film. It should, of course, interfere as little as possible with the acoustical properties of the film. It has been found that this desirable result is best achieved by weaving the fabric so that there is from about 40% to about 80% open area, that is, the fabric itself will take up from about 20% to about 60% of the total area covered by the film. The result of this arrangement is that the film contacts the surface of the fabric at only a relatively few points. If it were otherwise, or if the fiber were imbedded in the film, the films freedom of vibration would be impaired with the result that its desirable acoustical properties would also be impaired.

The film is bonded to the reinforcing fabric by an adhesive. The choice of adhesive is not critical although one should consider the conditions under which the final product will be used. In areas where fire is a problem, an inflammable adhesive would obviously be undesirable. If the final product will be subject to extreme fluctuations of temperature, naturally the adhesive must be one which will maintain its integrity under these conditions. Adhesives which may be successfully utilized in the practice of this invention include, among others, polyester adhesives, adhesives of the chlorinated polyvinyl type such as chlorinated polybutadiene and modified synthetic rubber types such as the chlorinated butadiene-styrene type.

In bonding the fabric to the film, care must be taken not to force the film into the fabric thus meshing the two materials into an integral unit in which the film loses its freedom of vibration. Such a product would be acoustically useless. The contact of the film with the reinforcing fabric must be a surface to surface contact so that the film and fabric are as much as possible in separate planes.

The preferred film thickness is from about 0.0035 mil to about 0.0075 mil although thinner and thicker films, for example from 0.0015 to 1 mil may be used. Films thinner than this are less preferred since they are more difficult to manufacture, more expensive, and there is loss of strength as the thickness of the film decreases. As the thickness of the film increases beyond the above limits the acoustical properties become less desirable. Hence films which are too thick are not useful in this invention.

In preferred embodiments of the invention, the film will be embossed. A number of suitable embossing designs are available. These include, for example, embossings of diamond, square, oblong, round or rectangular shape. Embossing may be effected by conventional methods such as press rolls, press plates and calendar rolls with suitable patterns on the facings, care being taken not to enmesh the film in the fabric.

A preferred design comprises closely spaced, relatively small, e.g. of the order of ⅛ inch, diamond shapes having a raised, round, pimple shaped area within the periphery of the diamond. With this design the film is broken away from the fabric at the centers of the patterns. This factor is significant for three reasons: (1) It gives the film more opportunity to stretch and thus contributes to its flexibility; (2) there is less impedance to vibration of the film with sound waves so that it is more sound transparent at low frequencies; and (3) it imparts the desired texturizing for light diffusion and thus improves general appearance. This particular embossing design is referred to herein as the nail head and diamond design.

In one of its uses the valuable product of this invention is employed to protect sound absorbent materials on the walls or ceiling of a room and to complement their sound level reducing properties. Thus various sound absorbents are protected by affixing a reinforced plastic film to at least one surface, the films are from about 0.0015 to about 1 mil in thickness and may be bonded to a variety of loosely woven fabric materials in which the open area of the weave is from about 40% to about 80%. The acoustical material protected retains its efficiency over a much longer period than unprotected absorbent. The reinforced film may be affixed to the acoustical material in a variety of ways including staples and tacks. The material to be protected may be simply sewn into a bag made of the reinforced film.

In a particularly useful form of this invention the reinforced film is employed in combination with the sound attenuating acoustical material described and claimed in copending patent application Ser. No. 93,159, filed Mar. 3, 1961, now Patent No. 3,253,947, issued May 31, 1966. This combination provides a novel product. The invention described in that application is a sound attenuating material comprising a fabric base having an elastomeric film adhering to at least one of its surfaces and is referred to herein as a septum sheet. At least about 1 to 15 times its weight in discrete highly dense solid particles is dispersed in the film. The product is characterized by its limpness and substantial non-resonance. The elastomeric film is a rubber-like, flexible polymer, preferably a cured vinyl polymer or copolymer although others can be used. Polymers and copolymers derived from vinyl chloride, vinylidene chloride, butadiene, acrylonitrile or esters of acrylic or methacrylic acid may be mentioned by way of example. Typical fibers that can be used include jute, hemp, cotton, wool, nylon, glass etc. These may be chemically treated to be fire retardant if desirable. A typical fabric is one containing about 83%

asbestos with the balance composed of other fibers, such as cotton. The preferred solid particles are composed of lead although other metals such as aluminum, barium, beryllium, tin, cadmium, tungsten, mercury or zinc or their oxides may be employed. In preferred modifications the particle mesh is from about 10 to about 60 Tyler screen mesh. About 30 to 60 mesh of granular or pelletized lead is especially preferred. The product is prepared by dispersing particles throughout the elastomeric substance in amounts from about 1 to 15 times the weight of the elastomer to be applied to the fabric. This dispersion is then applied to the fabric and cured.

The product of said application may, because of its flexibility, be used in various applications. In this respect it is similar to the product of this invention, the combined product may be fastened to walls or ceilings and may be used as a housing to cover engines or other noise sources.

In an especially preferred aspect of the invention, a loosely packed sound absorbing material is sandwiched between the reinforced film and the sound septum. Useful sound absorbing materials include for example, loose fibrous mineral inorganic substances such as fiber glass, rock wool or asbestos in any of its various forms such as chrysotill, amosite or crocidolite.

This assembly combines sound reflectance, sound absorption and sound attenuation to provide a product which is especially effective in the reduction of sound transmission from a noise source.

This aspect of the invention may be better understood by reference to the drawing which illustrates a particularly useful embodiment of the invention. In the drawing, **1** is the plastic film, **2** is the adhesive, **3** is the loosely woven reinforcing fabric and **4** is the loose fibrous substance. The septum sheet includes **5**, the woven fabric, **6** elastomeric substance and **7**, the pellets of highly dense metal or metal oxide.

In operation, the illustrated embodiment would be used to reduce sound transmission, for example from an engine by being supported on a frame surrounding the engine with the plastic film facing the sound source. Both high and low frequency sound energy would strike the film. Most of the high energy sound is reflected. Most of the low energy sound passes through the film where it is absorbed, chiefly in the loose fibrous material, or attenuated chiefly in the septum sheet. The small amount of high frequency sound which passes the reinforced film is also dissipated mostly by attenuation in the septum sheet.

A useful sound level reducing product functioning principally by reflectance and absorption may be obtained by simply covering at least one surface of a loose fibrous sound absorbing material with a reinforced film. This is most simply accomplished by loosely filling a bag formed from the reinforced film with the selected sound absorbing material. In the alternative, the sound absorbing material may be tacked to a wall or other support and then faced with reinforced film.

A number of experiments have been performed, the explanation of which will help to clarify the novel aspects of this invention.

In one of these experiments the sound absorption coefficient at various frequency levels was determined for two separate layers of fiber glass of 1.5 pounds per cubic foot density protected on the noise source side with an asbestos reinforced Mylar film of this invention. The results are reported in Table 1. The sound absorption coefficient is defined as the ratio of sound energy which is absorbed by the material under study to the sound energy incident upon it. A high sound absorption co-efficient indicates good sound level reducing properties through absorption. It will be noted from Table 1 that the fabric reinforced film of this invention backed with sound absorbing material has good sound level reducing properties through absorption at low frequencies, but that the efficiency in this respect drops off at high frequencies.

TABLE 1

Frequencies	125	250	500	1000	2000	4000
Sample 1	.16	.36	.89	.43	.19	.11
Sample 2	.09	.57	.86	.38	.14	.09

In a somewhat similar experiment employing similar materials, the fiber glass was protected on both surfaces with an asbestos reinforced Mylar film of this invention. In this experiment the sound reduction in decibels was measured by placing the material under study over an opening between a completely reverberant room with a noise source therein and an anechoic chamber, i.e., a completely dead type of chamber. The results are reported in Table 2 where it will be noted that sound reduction is poorest at low frequencies and increases with increasing frequencies.

TABLE 2

Frequency in c.ps.:	Sound reduction in decibels
125	8
177	15
250	10
354	10
500	11
707	14
1000	21
2000	33
4000	44
Avg.	18.2

Table 3 shows the results of a similar test employing only the septum sheet described and claimed in the above-mentioned copending application Ser. No. 93,159.

TABLE 3

Frequency in c.ps.:	Sound reduction in decibels
125	28
177	35
250	32
354	31
500	35
707	38
1000	41
2000	48
4000	53
Avg.	37.7

It will be seen that there is a general increase in sound transmission loss with an increasing frequency over the frequency range tested and that the largest sound reducing effects through attenuation in the septum sheet are at the high frequencies. However, even at low frequencies, there is considerable sound transmission loss.

Table 4 illustrates the remarkable sound level reducing properties achieved by combining the reinforced film of this invention backed with fiber glass, i.e. the product reported in Table 1, with a septum sheet, i.e. the product of Table 3. In the experiment reported in Table 4, the reinforced plastic film is on the noise side of the product.

TABLE 4

Frequency in c.ps.:	Sound reduction in decibels
125	24
177	33
250	29
354	32
500	37
707	44
1000	51
2000	65
4000	71
Avg.	42.8

It will be seen that the average sound level reduction achieved with the product reported in Table 4 is much greater than achieved with the product of Table 2. It is also improved when compared with the product reported in Table 3. It should also be noted that sound level reduction is obtainable over the whole spectrum of sound frequency. Sound level reduction at low frequency is attributed to absorption in the fibrous intermediate layer. Sound level reduction at high frequency is attributed to reflection from the plastic film and attenuation in the septum sheet of any high frequency sound which passes through the plastic film.

In many applications it may be desirable to use, in combination with the reinforced film of this invention, a lighter weight product than that described in the aforesaid application. In these instances a flame retardant vapor barrier such as described and claimed in U.S. Patent 3,062,678 which issued on Nov. 6, 1962 may be employed.

Although, by way of illustration, the product of this invention has been principally described as it would be used in conjunction with a flexible acoustical material, it is obvious that it is not so limited. It is entirely possible, for example, to construct a sound barrier of solid block surrounding a noise source and to protect both the inside and outside surfaces or either one of them with the reinforced film of this invention. Many other variations are possible without departing from the spirit or the scope of this invention and it is therefore to be understood that the invention is to be limited only by the appended claims.

We claim:

1. A flexible acoustical product comprising a reinforced plastic film from about 0.0015 to about 1 mil thick characterized by being substantially sound transparent at low frequencies and substantially sound reflective at high frequencies bonded to the surface of a loosely woven fabric base, said fabric base taking up from about 60% to about 20% of the total area of the film.

2. A flexible acoustical product comprising a reinforced plastic film from about 0.0015 to about 1 mil thick characterized by being substantially sound transparent at low frequencies and substantially sound reflective at high frequencies bonded to the surface of a loosely woven asbestos base, said asbestos base taking up from about 60% to about 20% of the total area of the film.

3. A flexible acoustical product comprising a reinforced plastic polyester film from about 0.0015 to about 1 mil thick characterized by being substantially sound transparent at low frequencies and substantially sound reflective at high frequencies bonded to the surface of a loosely woven fabric base, said base taking up from about 60% to about 20% of the total area of the film, said polyester film being a chemically resistant, light transparent, substantially water-vapor proof condensation product of ethylene glycol and terephthalic acid.

4. A flexible acoustical product comprising a reinforced embossed plastic film from about 0.0015 to about 1 mil thick characterized by being substantially sound transparent at low frequencies and substantially sound reflective at high frequencies bonded to the surface of a loosely woven fabric base, said fabric base taking up from about 60% to about 20% of the total area of the film.

5. A flexible acoustical product comprising a reinforced plastic film embossed with a nail head and diamond design from about 0.0015 to about 1 mil thick characterized by being substantially sound transparent at low frequencies and substantially sound reflective at high frequencies bonded to the surface of a loosely woven fabric base, said fabric base taking up from about 60% to about 20% of the total area of the film.

6. A flexible acoustical product comprising a reinforced plastic film from about 0.0015 to about 1 mil thick characterized by being substantially sound transparent at low frequencies and substantially sound reflective at high fre-

quencies bonded to the surface of a loosely woven fabric base, said fabric base taking up from about 60% to about 20% of the total area of the film, said reinforced film in surface to surface contact with at least one surface of a sound absorbent material.

7. A flexible acoustical product comprising a reinforced plastic film from about 0.0015 to about 1 mil thick characterized by being substantially sound transparent at low frequencies and substantially sound reflective at high frequencies bonded to the surface of a loosely woven fabric base, said fabric base taking up from about 60% to about 20% of the total area of the film, said reinforced film being in surface to surface contact with at least one surface of a loose, fibrous mineral inorganic sound absorbent material.

8. A flexible acoustical product comprising a reinforced plastic film from about 0.0015 to about 1 mil thick characterized by being substantially sound transparent at low frequencies and substantially sound reflective at high frequencies bonded to the surface of a loosely woven fabric base, said fabric base taking up from about 60% to about 20% of the total area of the film, said reinforced film being in surface to surface contact with at least one surface of asbestos sound absorbent material.

9. A flexible acoustical product comprising a reinforced plastic film from about 0.0015 to about 1 mil thick characterized by being substantially sound transparent at low frequencies and substantially sound reflective at high frequencies bonded to the surface of a loosely woven fabric base, said fabric base, taking up from about 60% to about 20% of the total area of the film, said reinforced film being in surface to surface contact with at least one surface of fiber glass sound absorbent material.

10. A flexible acoustical product comprising a reinforced plastic film from about 0.0015 to about 1 mil thick characterized by being substantially sound transparent at low frequencies and substantially sound reflective at high frequencies bonded to the surface of a loosely woven fabric base, said fabric base taking up from about 60% to about 20% of the total area of the film, a first inner layer comprising a loose, fibrous mineral inorganic sound absorbent material and a second inner layer comprising a fabric base bearing on at least one surface a continuous elastomeric film containing dispersed in discontinuous relationship therethrough at least about one to fifteen times the weight of said elastomeric film of discrete particles of a highly dense metallic solid.

11. A flexible acoustical product comprising a reinforced plastic film from about 0.0015 to about 1 mil thick characterized by being substantially sound transparent at low frequencies and substantially sound reflective at high frequencies bonded to the surface of a loosely woven fabric base, said fabric base taking up from about 60% to about 20% of the total area of the film, a first inner layer comprising a loose, fibrous mineral inorganic sound absorbent material and a second inner layer comprising a fabric base bearing on at least one surface a continuous elastomeric film containing dispersed in discontinuous relationship therethrough at least about one to fifteen times the weight of said elastomeric film of discrete particles of lead.

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