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PRESSURE-INSENSITIVE, SANDWICHED, ACOUSTIC MATERIAL HAVING A HONEYCOMB CORE

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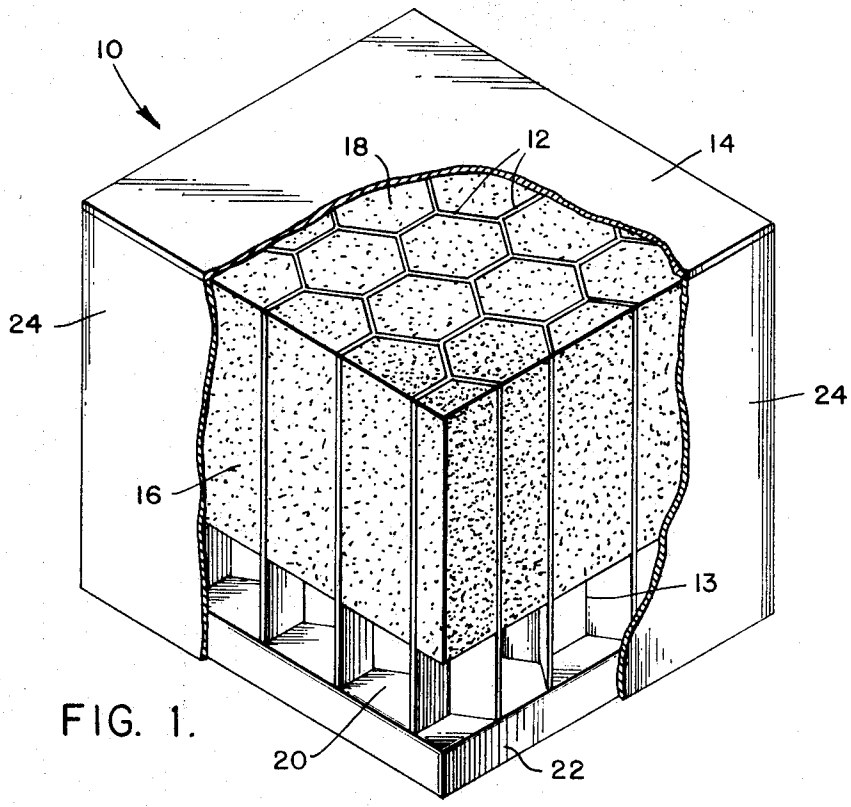


FIG. 1.

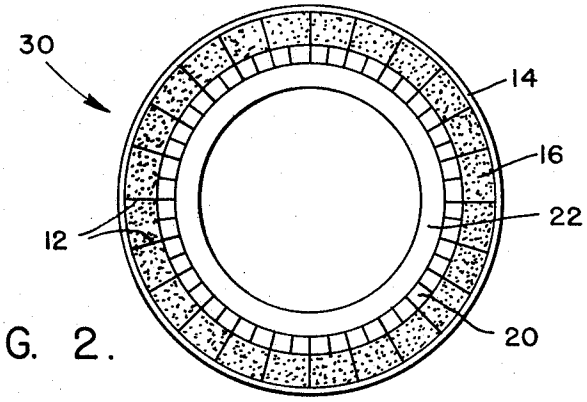


FIG. 2.

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PRESSURE-INSENSITIVE, SANDWICHED, ACOUSTIC MATERIAL HAVING A HONEYCOMB CORE

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ABSTRACT OF THE DISCLOSURE

This invention relates to a pressure-insensitive, sandwiched, acoustic material having a honeycomb core, at one end of which is a compliant wall or skin and at the other end of which is a noncompliant wall. Between the walls, the honeycomb cells are filled part way with a matrix of air-mixed aluminum flake and polyurethane, a film of gas adhering to each flake, the balance of the cell, at the noncompliant wall, being filled by a gas at ambient pressure.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

The purpose of this invention is to provide a composite, pressure-insensitive structure which may be used as an acoustic absorber underwater, for example with transducer arrays, to absorb undesirable acoustic reflections.

In the prior art, acoustic absorbers, such as the B. F. Goodrich Co.'s product called "Soab," utilize the adsorption of an adhered gas film on the surface of aluminum flakes suspended in a matrix of butyl rubber. While acoustic absorption is good to depths of about 100 feet, hydrostatic pressure causes the adhered gas film to collapse, and the absorption of acoustic energy is pressure-sensitive and has a minimum value at depths below 200 feet.

In contrast, the acoustic material of this invention, due to its construction, is pressure-insensitive. The material consists of a sandwiched wall construction having a rigid honeycomb core, for example, of aluminum, capable of being subjected to a substantial compressive load. The inner facing at one end of the core is a noncompliant wall element, such as an aluminum plate of sufficient thickness to be rigid. The outer facing, exposed to the acoustic energy, at the other end of the core is a compliant skin, such as stainless steel sheeting, a few mils thick. In addition, except where the acoustic material is used in a spherical configuration, lateral, rigid, and airtight walls are required.

Starting at the end adjoining the outer facing, the honeycomb cells are filled with a matrix of polyurethane containing a dispersion of aluminum flakes, for absorbing the acoustic energy. A film of gas adheres to the surface of each aluminum flake. The honeycomb cells are not filled to their full length, leaving a void in the end of the cells adjoining the inner, rigid, facing. A gas at ambient pressure is loaded into the voids at the inner facing end of the honeycomb cells.

An important feature of this invention is that the absorptive, acoustic, material is not subjected to hydrostatic pressure. Instead, the hydrostatic pressure is borne by the compliant skin in tension and the cellular support in compression, allowing the gas film absorber to be at ambient pressure equilibrium with the confined gas.

There are three different types of materials involved in the acoustic energy absorption: a hard material, the aluminum core structure; an intermediate absorbing material, the matrix of polyurethane and the aluminum flakes, with their adhered gas; and a soft material, the entrapped air.

The honeycomb core structure, which carries practically the whole load, being quite rigid, is not easily compressible. However, it does deform to some extent, causing a very slight compression of the entrapped air, more or less independently of the elastic compression of the honeycomb core. This is so because, for a given pressure, the mechanical modulus of the honeycomb core changes very slightly causing a correspondingly very slight change in the air pressure of the entrapped gas, and therefore an equally slight change in the volume of the gas.

While all the details about how the material herein described serves as an acoustic absorber are not known, the following details supply a plausible explanation of what probably transpires. When acoustical energy impinges upon the sandwiched acoustic material, it first produces a stress against the compliant skin, buckling it inwardly slightly, which causes a slight deformation of the absorber material, and therefore a slight compression of the entrapped gas.

It is believed that the acoustic energy absorption comes about from the frictional losses due to the sliding action of the aluminum flakes against the polyurethane, that is at the interface between the flakes and the polyurethane, thus causing a viscous loss. Apparently, the aluminum must be in a form having a large ratio of surface area to volume, inasmuch as aluminum spheres interspersed within a polyurethane binder in air do not work nearly as well. Moreover, if the polyurethane binder is mixed with the aluminum flakes in a vacuum, absorption of acoustical energy is greatly reduced, again indicating that the mechanism of energy absorption involves frictional losses involving the adhered layer of gas on the surface of the aluminum flakes.

The acoustic pressure on the polyurethane should not exceed roughly 25 to 50 p.s.i. If the pressure becomes excessive, the frictional action between the aluminum flakes and the polyurethane is inhibited and the absorption of acoustic energy does not take place. At any rate, the foregoing is believed to account for the action which takes place.

Accordingly, an object of the present invention is to provide an absorbing acoustic material which is not subjected to hydrostatic pressure.

Another object is the provision of an acoustic material whose honeycomb structure gives it light weight and great structural rigidity in the direction of load-bearing.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description, when considered in connection with the accompanying drawings, in which like reference numerals designate like parts throughout the figures thereof and wherein:

FIG. 1 is a diagrammatic view, with two lateral side walls and part of the top compliant facing partially removed, of the pressure-insensitive acoustic material of this invention.

FIG. 2 is a cross-sectional view of the pressure-insensitive acoustic material in either a cylindrical or circular configuration.

Referring now to FIG. 1, therein is shown a pressure-insensitive, sandwiched, acoustic material **10** comprising a honeycomb core **12** of rigid material, for example, aluminum, having a direction of maximum support, or direction of maximum load bearing **13**. The direction of maximum support **13**, in the figure, coincides with the lines of intersection of the cell walls of the honeycomb structure. A compliant skin **14**, which may be a sheet of stainless steel a few mils thick, is fastened at one end of

the core **12** at an angle, usually a right angle, to the direction of maximum support **13** of the honeycomb core **12**. Absorber material **16** partially fills the cells **18** of the honeycomb core **12**. Air-mixed aluminum flake and polyurethane may constitute the absorber **16**. A gas **20**, for example air at ambient pressure, fills the unfilled part of the honeycomb cells **18**. A noncompliant rigid skin **22**, which may be an aluminum plate, is fastened in an airtight manner to the other end of the honeycomb core **12**, and, when planar, is parallel to the compliant skin **14**. Where the sandwiched acoustic material **10** has parallel sides, lateral side walls **24** would complete the structure **10**.

With respect to alternate embodiments, the compliant facing or skin **14** need not be of metal, but may be a flexible plastic or a fiber-reinforced resin. The facings **14** and **22** need not be planar as shown in FIG. 1, but may be cylindrical or spherical as shown by the cross-sectional view of the embodiment **30** shown in FIG. 2. A cylindrical configuration for the sandwiched acoustic material would require the use of only two side walls or end plates, corresponding to the lateral walls **24**, while a spherical configuration would require none.

The supporting material for the core structure **12** need not be a columnar metal, but may be of some other transversely compliant material, such as flattened tubing.

The gas **20** at one end of the honeycomb structure **12** of the acoustic material **10** need not be air, but may be nitrogen or some other gas or mixture of gases.

The absorber material **16** need not be a primarily single-material absorber but may be a composite mixture, such as a gas, or a mixture of gases, aluminum flake, encapsulated low-velocity liquid, and a resin matrix.

The absorber material **16** may be of a type such as polyurethane or rubber which adheres very strongly to the walls of the cellular core **12**. In this case the compliant skin **14** need only be tacked onto the core **12** inasmuch as the absorber material **16** will not be shifted by the gas **20** in the cell pockets **18** below it, even if the gas has been compressed to some extent due to the depth of the water in which the sandwiched acoustic material **10** is located.

However, where the absorber material **16** is loosely packed in the top of the cells **18**, the compliant skin **14** would have to be secured to the core structure **12** in an airtight manner.

The sandwiched, acoustic, material **10** of this invention can also be used for matching the acoustic impedance of a medium making contact with the compliant skin to that of the medium making contact with the non-compliant

facing **22**. To accomplish this, an acoustic matching section would be used between the noncompliant facing **22** and the absorber **16** in place of the gas **20**, as disclosed in the same copending application.

The noncompliant facing **22** may be part of the mechanical structure upon which the acoustic material **10** is mounted; e.g., a deep-submergence pressure vehicle.

We claim:

1. A pressure-insensitive, sandwiched, acoustic material comprising;

a honeycomb core of rigid material, defining at least one direction of maximum support;

a compliant skin secured at one end of the core at an angle to the direction of maximum support of the honeycomb core;

absorber material partially filling the cells of the honeycomb;

a noncompliant skin sealably secured to the other end of the honeycomb core and at the same angle to the direction of maximum support as the compliant skin; and

entrapped gas filling the unfilled part of the honeycomb cell.

2. The acoustic material according to claim **1**, wherein the direction of maximum support is at right angles to the two skins.

3. The acoustic material according to claim **2**, wherein the two skins are planar.

4. The acoustic material according to claim **2**, wherein each of the skins are cylindrical and have a common axis.

5. The acoustic material according to claim **2**, wherein each of the skins are spherical, the spheres having a common center.

6. The acoustic material according to claim **2**, wherein

the honeycomb core is aluminum;

the compliant skin is stainless steel sheeting;

the absorber material is a matrix of air-mixed aluminum flake and polyurethane;

the entrapped gas is air; and

the noncompliant skin is an aluminum plate.

References Cited

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ROBERT S. WARD, JR., Primary Examiner